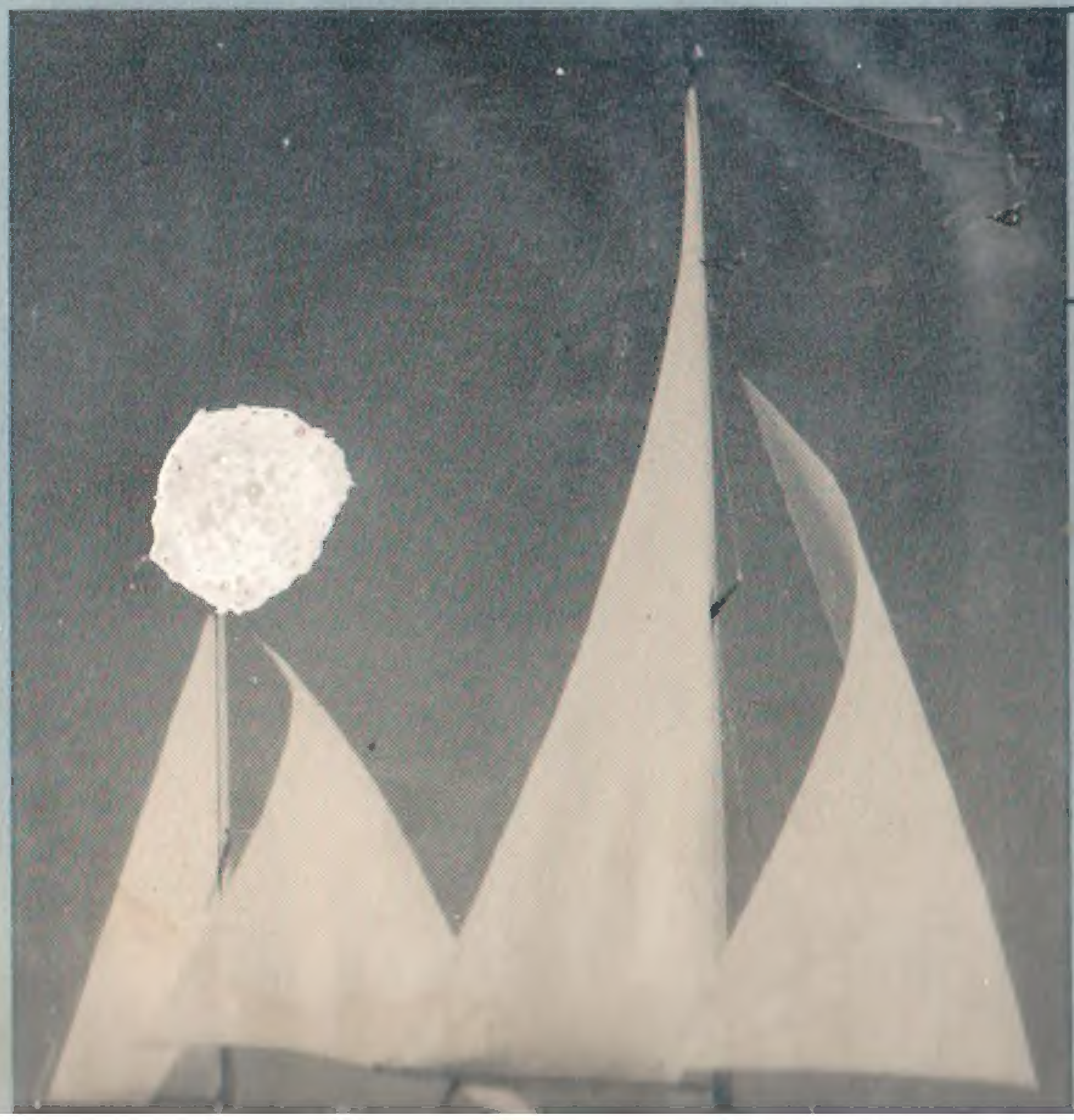
# STANDARD HANDBOOK OF PLEASURE BOATS

An illustrated guide to the care and repair of your boat

Photographs and Construction Plans Make Every Instruction Easy to Follow

The Appendix Includes Useful Tables and Charts You Will Need Again and Again

BY ROBERT J. SHEKTER



**Step-by-step instructions on buying, testing, repairing, and maintaining motor craft, auxiliaries, and sail boats.**

**These chapters teach you about:**



STANDARD HANDBOOK OF PLEASURE BOATS

BY ROBERT J. SHEKTER



$5.95

## STANDARD HANDBOOK OF PLEASURE BOATS

ROBERT J. SHEKTER

*35 plans and diagrams; 10 halftones*

The *Standard Handbook of Pleasure Boats* is a complete manual to the care and repair of pleasure craft. It begins by telling how you can choose the right boat. You must get the boat you can afford and yet you must have a *good* craft. The author, who has sailed all his life and now earns his living as a boat designer, has prepared a practical check list of what to look for in both new and used boats.

When you have found the craft that appeals to you most, how do you test it for seaworthiness? Step-by-step you are shown how to conduct dockside and open-water tests of powerboats, auxiliaries and sailboats. You are told what the danger spots are and you are given sound advice on whether you can make the proper repairs yourself inexpensively. You are instructed exactly how to put the boat in ready-to-use condition; you learn the elements of refinishing, caulking, commissioning the engine, checking the electrical system, fueling, galley preparations, water supplies and safety precautions. Your engine, whether outboard or inboard, is completely described. You are shown what to do when something goes wrong with your engine and, even more important, you are told how to detect what may go wrong before it happens. There is a full chapter on rigging and sails. With pictures, diagrams, and an exceptionally clear text you can learn how to replace spars and masts, how to test and, if necessary, recut sails, how to choose the right ropes for the right job, and how to recondition blocks and winches.

*(Continued on back flap)*

Pictured on the jacket is the famous *Amathea I*, a 37-foot fiberglass auxiliary centerboard yawl designed and constructed by the author. The *Amathea*, fast enough for ocean racing, has living accommodations for four to six people.

*(Continued from front flap)*

One of the most helpful features of the *Standard Handbook of Pleasure Boats* is the practical advice about materials and tools. Recently there have been developed new paints, synthetic construction materials, better hardware, and efficient tools of all kinds. Mr. Shekter, a designer and boatbuilder himself, gives you the benefit of many years of practical experience. Often it is the shortcut that makes the difference between drudgery and fun, and here is a book that passes on to you every hint and "secret" that will make keeping a boat easy.

The *Standard Handbook of Pleasure Boats* is not a guide to piloting and navigation. It is a guide to how to keep your boat safe and how to have confidence and fun in your sport. One of the most useful chapters concerns the galley, for the proper management of this "department" is essential to the enjoyment of a cruise. You learn what kitchen utensils to take along, what foods keep best aboard ship, and how to prepare good food. Another important chapter contains practical advice on running your boat. Here is information on tides and currents, compass readings, anchoring, what to do in case of sudden storms, and how to handle your boat if you run aground or damage the hull. Finally there is a complete chapter on safety procedures: how to choose first-aid kits, prevent accidents, avoid seasickness, and rescue a "man overboard."

The *Standard Handbook of Pleasure Boats* is fully illustrated with photographs. There are 35 plans and diagrams and over 20 check lists and tables. The useful appendix includes valuable tables on the tensile strength of ropes, the weights and qualities of wood, tables of resins and their characteristics, and many more. There is a glossary of terms most useful to the boatowner.

## ABOUT THE AUTHOR

Robert Shekter has been cruising inland waters and open sea since he was a boy. He has always done his own designing, maintenance and navigation; and the famous *[illegible]nathea*, a fiberglass and wood 37-foot [illegible]l, pictured on the jacket was both designed and built by him. Mr. Shekter's authoritative articles have appeared in *Motor Boating, Popular Boating, Rudder,* and *Yachting*.

"This book can keep paying for itself over and over with page after page of such specific instructions and straightforward opinion. The new boatman will be pleased with the way he can find here the answer to an individual problem, while the more experienced sailor will highly value the completeness of the source material available here."

—WILLIAM TAYLOR McKEOWN
Editor, *Popular Boating*

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Pleasure Boats

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ROBERT J. SHEKTER



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To

My father, for a lifetime of patience and understanding;
and my mother, for teaching me to draw as an artist
while designing as an engineer.

# Contents

CHAPTER 1

# The Right Boat for the Job

THE PROSPECTIVE BUYER of a boat today has a field of choice larger than any before. Hulls, engines, sails, and hardware are available in every range of utility, quality, and price. This first chapter will help you to define your needs in a boat and to narrow your field of selection to one basic type. After you have read this chapter and Chapter 2 you will know enough about the fundamentals to choose a safe, economical boat. Then, when you have judged the boat on these fundamentals, your final choice will be based upon your own taste and budget.

## KINDS OF PLEASURE BOATS

Pleasure boats can be divided into four general types: the runabout, the cabin cruiser, the sailboat, and the auxiliary-powered sailboat. Each type has certain recommendations and each also has its disadvantages. Moreover, their uses often overlap so that it is possible to find a happy compromise for the entire family in a single boat. We must try, therefore, to discover the basic utility of each boat before we can go on to the fundamentals of design and construction.

### The Runabout

The runabout is the most popular boat on the water today. Driven by an inboard or outboard engine, it is a light, open powerboat, making up the greatest part of the current boating scene. The runabout is a comparative newcomer to boating, but in the years since the war it has become ubiquitous. It can be seen zooming across Crater Lake, a mile above

Photo 1-1. This 15′ outboard boat is designed for fishing and ski-towing.

Photo 2-1. A 14′ outboard runabout.



sea level in the Colorado Rockies; along the edge of the Gulf Stream; on the western side of the Bahama Islands, indeed, almost everywhere. The reasons for its popularity include its low initial cost, its facility for handling from a trailer, its speed and sportiness, and its easy care and maintenance. Strikes against runabouts, however, are these: their dollar value depreciates rapidly with time; their designs are often stylized, which makes them hard to sell at all when they are out-of-fashion; they offer no protection to the crew when the weather turns really rough, although they often have excellent spray hoods for ordinary weather. Also, while the runabout is well suited to the fisherman, it makes a rather poor family boat because its operation is really too simple. In a boat where one person can and must do all the piloting, there are no important jobs left for the rest of the family. This fact, added to a high noise level that almost rules out conversation, often makes these boats a bore rather than a sport, once the initial novelty has worn off.

**The Cabin Cruiser**

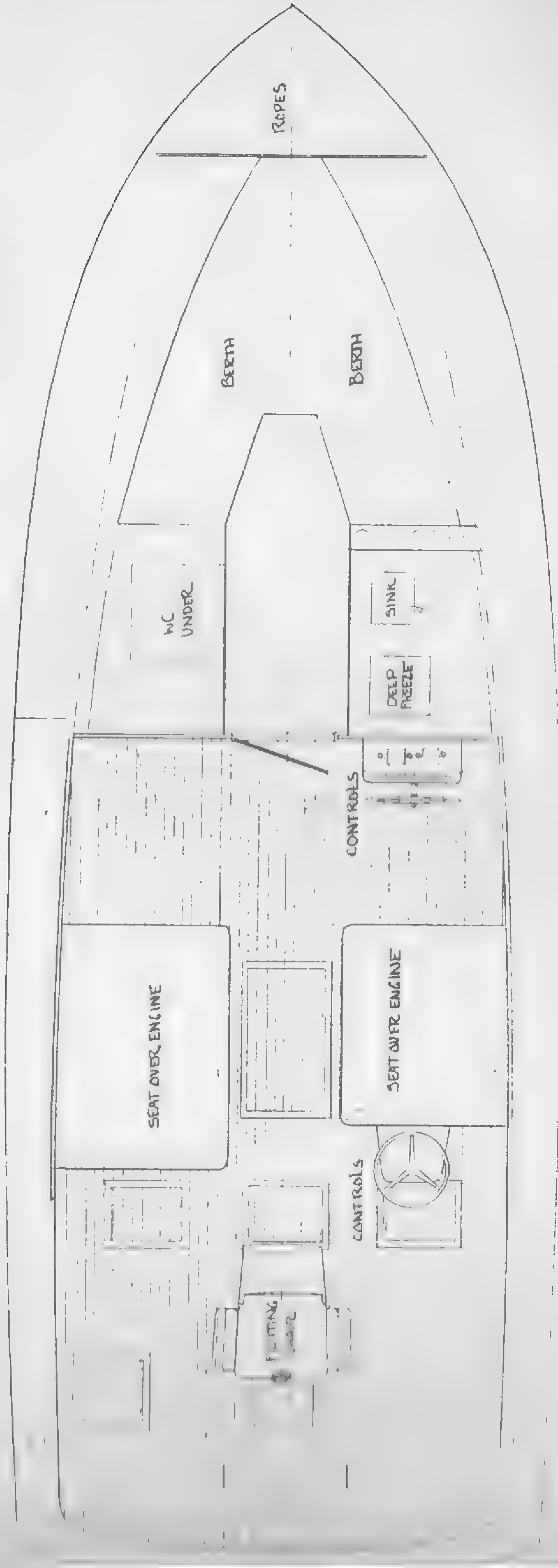
The cabin cruiser, even in its smaller sizes, seems a much more interesting craft than the runabout. See Photo 3-1. The features which make a boat a cruiser include one or more full-size sleeping berths in a truly watertight cabin, some sort of galley providing food storage (a boat of any size can carry a portable icebox), a safe, simple stove, and a fixed or portable toilet. A great many small cruisers are designed so that seats can be turned into dinettes and dinettes can be converted into beds. Such boats may be quite appealing in the showroom, but work out badly in actual practice. Not only do the fixtures swell and become hard to work once the boat is in use but they never *really* do any of their several jobs satisfactorily. Moreover, anyone who has ever built a boat will assure you that it costs more in time and materials to make a multipurpose unit, such as the dinette-berth, than to construct each as a separate device. Because of this you will pay a greater percentage of the total cost of the boat for these gadgets, and less of the total cost for the quality of the boat itself.

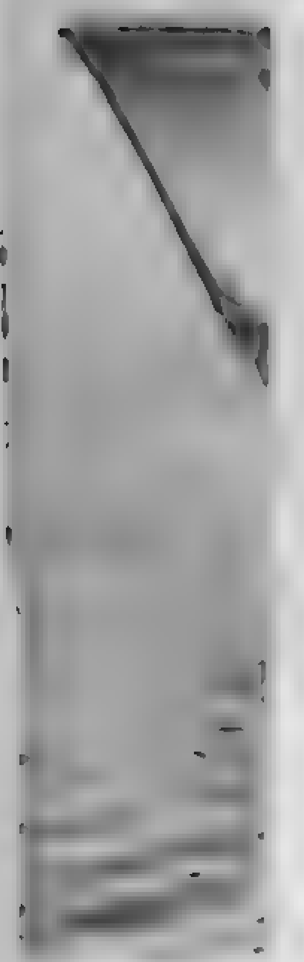
Perhaps the greatest value of the cruiser is that it provides an interest for every member of the family. From running the galley to handling the mooring lines, maintaining the engine and piloting the boat, the family owning a cruiser will find new interests always opening ahead of them. In the beginning, seamanship, boat handling, and maintenance are exciting fertile fields to explore. As proficiency develops and the fundamental routine aboard the boat becomes automatic, the lure of more distant harbors offers new challenges. Simple weather predicting and basic meteorology become absorbing subjects for study. The distaff side of the family can take an active part in predicting the weather, doing chart work and navigation. Perhaps because the cruiser has galley and living arrangements similar to those on shore, the most delightful part of cruising consists in

Photo 3-1. The cabin cruiser makes perhaps the best boat for the entire family. It "sleeps in," has a galley for the hungry sailor, and demands active participation in its operation from every member of the crew.

making the boat more homelike. Moreover, aboard a small cruiser all hands discover that it is fun to help with the "housework." Soon, the mechanics of living on board become simplified and automatic as each member of the crew learns to contribute to the boat in the way he is best able. Once such living has become routine, the beauty of the sea, the harbors and the lights abounding in them, will add further stimulus. Because the cruiser encourages the participation of the entire crew, be certain, in choosing your boat, that the helmsman's seat is not isolated somewhere inside the boat, away from the cockpit. With such an arrangement, the man at the wheel will find himself all alone in the shade while his friends and family are sunning themselves in the cockpit chairs. If the boat you select has its controls forward, see if you can't arrange a simple tiller aft so that you can join the party.

Plate 3-1. Cabin plan of the Rybovich sport fisherman, showing dual control installation for fighting fish and its clean, open cockpit.





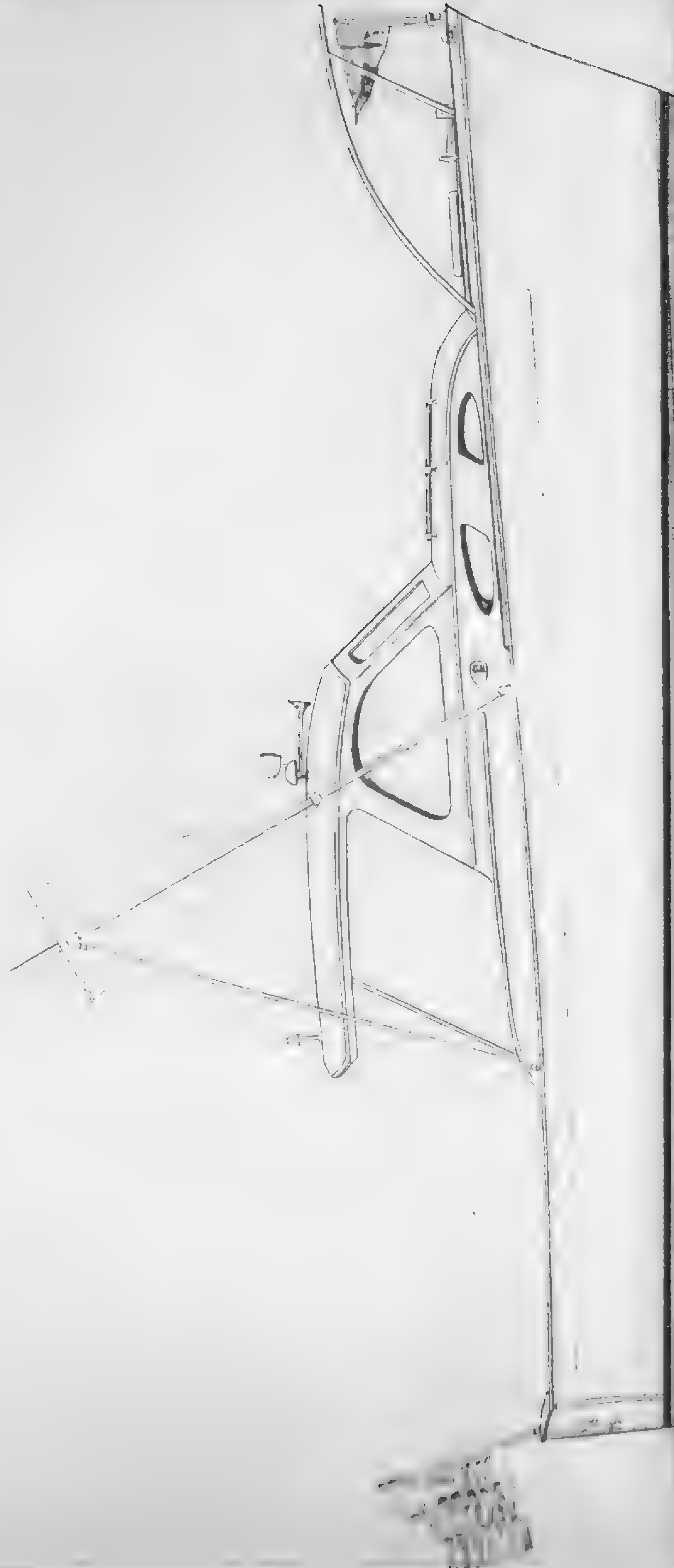


Plate 2-1. A sport fisherman designed and built by Rybovich and Sons, Palm Beach, Florida. This specialized fishing boat has good cruising

Photo 4-1. This cabin cruiser sleeps four and has a maximum speed of 26 mph.

The cruiser will be easy to sell when the time comes for a different boat and, if you have been careful to choose one which is not stylized with chrome and fins, she will not have lost her value because she has become outmoded. Each year many people who began boating in runabouts graduate into cruisers, so that the latter's resale value tends to remain very high. Also, because the interior of the boat is protected from the weather by the cabin, the annual depreciation of a cruiser is considerably less than that of a runabout or an open sailboat. Most small cruisers today are of such shape and weight that they can be easily moved about on a trailer. This enables the owner to vary his cruising ground with each vacation; one trip may take him to the clear green waters of the Florida Keys; another jaunt lets him taste the pine-fresh air of some lovely New Hampshire lake.

The disadvantages of a cruiser are: a higher initial cost (although the fuel cost is generally low); a slightly higher maintenance cost; if the cruiser is of trailer size, it will require a heavy-duty trailer, which also increases its overall cost in comparison to the runabout; because it is a heavier boat, the cruiser may be somewhat harder to handle from a trailer "in the field," although there will be no difference, compared to a runabout, in handling it from a regular launching area.

### The Sailboat

The sailboat is the most highly developed type of boat on the market today. While available in quite a variety of rigs, classes and forms, all sailboats have in common the virtues of silence and simplicity. These boats are the best in which to learn seamanship. When you have mastered the sailboat, you can easily handle any other type of craft, regardless of its size or power. Besides being quite silent and easy to handle, the sailboat is low in both initial and operating costs and has a high resale value. There is no engine to maintain and since the advent of the new synthetic sails upkeep has become minimal. Even the highly refined racing classes can be used for cruising, picnicking, or day sailing, so that the boat will provide unlimited interests for the entire family. As in the cabin cruiser and the auxiliary, each person on board can actively share in the operation of the boat. The study of wind, weather, tides and currents is genuinely absorbing and the knowledge gained from such study will be used continuously on board.

Photo 5-1. Simplicity of design heightens the beauty of this sailboat, tacking off the coast of Cape Cod.


Photo 6-1. This 20′ sloop has a 225 square foot sail area.

The most fascinating challenge of all boating is that of sailboat racing. Whether or not your sailboat is designed to a special class, active racing competition for it is available all over the world. The boat can be trailered or shipped anywhere in the world and enjoyed without the problems of locating fuel or equipment for its operation. Almost every major class of sailboat can also take part in international races. Such events are held annually all over the world and provide truly stimulating competition. The sailboat, particularly if she is of racing class, offers the greatest opportunity for the development of the sailor's skills.

The argument against the sailboat is that one can't expect to keep exact schedules without an auxiliary engine in his boat. In truth, no boatman ought seriously to predict his time of arrival. The sailboat with no engine has limited use as a cruiser: you may often waste valuable vacation time waiting for the proper wind to come, and, without power, you will be unable to explore many little streams and backwaters in which you must expect to encounter bridges, mud flats and adverse currents. Finally, if you decide to race, some members of the family must give up their sailing while others are engaged in the competition.

Photo 7-1. A 30′ cruising sloop.



## The Auxiliary-powered Sailboat

The auxiliary-powered sailboat may very well lay claim to being the most interesting type of vessel we know. When this class of boat is a true auxiliary, the engine is definitely subordinate to the sail plan and the boat combines excellent seagoing characteristics with useful low-cost cruising ability. These boats are available in all sizes. The variety of types ranges from shallow draft boats, with masts which can be lowered for extensive cruising on inland waters, to truly ocean-going vessels. Most of our finest ocean-racing boats today are auxiliaries. Even in the smallest sizes these boats can be designed and built so that they are able to make fast comfortable passages to any part of the world. It follows that the best racing boat is necessarily the best cruising boat. Obviously the cruiser is of no use at all if she can't sail well enough to take you where you want to go in a reasonable amount of time; also, no matter how fast a racer may be, she must take good care of her crew, enabling them to sleep in dry berths, cook hot meals, and handle her so easily that they don't become tired and inefficient.

The most important advantages in the auxiliary are these: safety; comfort; very low rate of depreciation on the used-boat market because of its inherent structural requirements (often, the value of a fine auxiliary boat will increase during its lifetime); long life expectancy (fifty years is not an uncommon age for a well-built auxiliary); excellent family boat, providing interest for both novice and old hand; an auxiliary cruiser can be an entirely self-contained world for considerable periods of time; unlimited cruising range.

The arguments against the auxiliary are its high initial cost and the need to look after two power plants: the sails and the engine.

The motor sailer, a boat in which sails and engine are of equal importance, has been deliberately overlooked in this discussion because, for the general size of boat we are considering, neither of its power plants is quite satisfactory and the boat, instead of being a satisfactory compromise between sail and power, is most often a poor performer with either one. In order to function as a motorboat, the motor sailer needs a powerful engine and a propeller to match. This propulsion machinery is placed in a hull designed so that it can also be driven by sail, resulting in a great deal of engine inefficiency. A sail plan which would be normal for an auxiliary of the same size will not have sufficient power to drive the extra weight and propeller resistance of the motor installation. On the other hand, problems of stability and human limitations of strength make it impractical to increase the size of the sails. A boat must be rather large to bridge these two extremes.

## BASIC TYPES OF CONSTRUCTION

Before we establish a general picture of the shapes, models, and hull forms which are best, we must briefly examine the several varieties of construction we find in boats today. Fundamentally, structure may be divided into wood, fabric, metal, and plastic.

### Wood Construction

Since the day when the first cave man drifted down a river aboard a tree trunk, wood has been the traditional material of boatbuilding. Although vessels have been constructed of metals since the middle of the nineteenth century and of synthetic materials during the past twenty-five years, wood has remained the favorite material for a number of excellent reasons. It combines great strength with moderate weight; it is easy to work, using hand tools; and, because of its long history, its sicknesses and their cures are well understood.

There are over two thousand varieties of wood, which makes it possible for designers and builders to meet accurately the physical requirements of each part of a boat. This enormous variety of woods has also encouraged many experiments in construction. Some of these experiments have become standard building methods. The principal types of these include boats built of plywood construction, lapstrake construction, battened-seam construction, and carvel construction. We'll look at each of these briefly now, but they will be covered in detail later in the chapter on "Construction."

#### *Carvel Construction*

The term "carvel," derived from the word "caravel," designates a lightly constructed, smooth-skinned boat built of caulked planks of wood laid along a skeleton of frames. Carvel construction has been so refined that some boats are very thinly planked, and have light strakes or battens inside the boat covering every seam. Although the seams are visible from outside the boat, the planking is quite smooth. This construction is actually one type of double planking. In older boats this was quite common but seam-batten construction is rare today. Because of this, and because they dry out easily and crack their seams open, such boats are not always good investments.

In the most common form of carvel planking, the caulked planks become watertight when they swell toward one another and seal themselves against the gasket which the caulking makes in the seams. This construction was developed several thousands of years ago and is now so refined that a skilled builder using selected lumber can make a boat which is light and inexpensive. Caulked planking, however, has its drawbacks. The planks are only fastened at the points where they cross frames, stem, stern, keel and sheer line, and they are unsupported between these points except for the mutual aid they grant one another through the pressure exerted by their caulked edges. This means that the boat is literally no stronger than its fastenings; there is no real continuity among the separate pieces of which the boat is built. Caulked planking will remain tight below the water line during the time the vessel is afloat, but it dries out on the topside, decks and cabin so that when the boat heels over, or when rain falls on the decks, water will come through the seams. Fresh water generates rot so that even though preservatives are used today, this method of building is fast becoming obsolete.



In strip planking, a very advanced form of carvel construction, the wood is laid in narrow lengths, each plank fitted tightly edge to edge with the plank above and below it. Fastenings run through two or more planks each and are closely spaced. This method of building is extremely light and strong. It requires very little framing because the bulkheads of the boat generally do the work of shaping the hull. Once the planks are fastened tightly to one another the boat will retain its shape without additional supporting structure. Strip plank construction is difficult to damage and, with modern materials, an injury is easy to repair. When strip planking is properly covered on the outside with a heavy layer of fiberglass-reinforced plastic, it makes a very useful low-maintenance hull of beautiful finish and appearance. This method of construction makes it possible to build an ultimately seamless hull without the expense of molds.

#### *Lapstrake Planking*

In lapstrake planking, each strip of wood overlaps its adjacent strip much like continuous shingles on a house. A generation ago this type of building was extremely popular. It has a long and honorable family history going back to the Viking vessels, some of the lightest, most seaworthy craft ever assembled. But the construction is now obsolete because of new and superior materials. It is subject to drying and rot because of its geometry which exposes the edges of the planks to the sun and air and which provides a resting place for fresh water, the initial stage of rot pathology. This same geometry, which encourages worm attack because of its increased surface, offers a tremendous amount of skin friction to the water or, in aircraft terms, "parasite drag." At the time of this writing there is a revival of lapstrake construction afoot because the very light, seaworthy Jersey sea skiffs were built in this manner. These sea skiffs are fishing boats which operate in all weathers and make comfortable pleasure craft. Some esoteric qualities of smooth, stable performance have been attributed to the deflection of water caused by the lapstrake hull, but this is all propaganda. The proof is that you don't see any of the really high-performance racing motor boats built lapstrake. Some of these fast boats, by the way, race in rough water, where they need all the stability and level riding qualities that they can get.

### *Plywood Construction*

Plywood represents a sort of middle step in the evolution of boatbuilding. Waterproof, exterior grade, marine plywood has been around for more than forty years, and the 115-foot motor yacht *Cabrilla,* designed by William Atkin, used it extensively as early as 1914. Plywood is a method of laminating several thicknesses of wood so as to get large panels of material having high uniform strength. By building such a sandwich, we distribute the forces which we can load upon the wood in such a way that the material becomes very resistant to deflection. Because plywood is available in large panels it enables us to build boats that have very few seams and fastenings. Plywood, when skillfully used with modern adhesives, makes strong low-maintenance boats that need no caulking. It is also particularly useful for spanning areas where additional supporting materials would be difficult to use; areas such as bulkheads, cabin tops, and decks.

A special application of plywood that is becoming increasingly common is its use as planking underneath a heavy fiberglass skin. In this type of construction, the plywood is ripped into narrow widths and secured diagonally over the skeleton of a boat. After the skeleton has been entirely veneered, the skin may be further built up with layers of glass and plastic. An alternate method of building a veneer-skinned boat is to continue with layers of plywood throughout the entire construction. This method is rarely utilized by amateur builders because it is difficult to obtain optimum strength and good finish qualities unless pressure-molding apparatus is used.

The arguments against plywood are that it is very heavy for its strength, it will not take compound curves, and, like any wood, it is susceptible to rot and to worm attack. Also, unless they are carefully constructed, boats built of plywood delaminate rather easily. In these cases of delamination, it is rarely the waterproof glue that comes apart. Instead, the several layers of wood, with grain running in all directions, will break down from their own swelling and shrinking. To protect against this, it is important that all plywood edges are carefully sealed against water in boat construction.

### Fabric Construction

Fabric construction means not only textiles but other flexible skins extended over a skeleton or inflated, like a rubber raft. The use of flexible skin boats has so far been limited primarily to collapsible vessels. While most of these boats are designed for life saving, there are several very good inflatable small craft which can be blown up to a general utility shape. Most of these boats are available as war surplus supplies, but especially fine ones are handled by Von Lengerke and Antoine in Chicago and Abercrombie and Fitch in New York. Inflatable boats made from Neoprene impregnated fabric stand up under rigorous usage and are easily repaired if injured. The safest models have several independent air chambers. The



treatment they like least is abrasion from beach rock; they also suffer from prolonged exposure to heat and light. The initial cost of these boats is rather high and their resale value is poor; however, as life-saving equipment, they are worth their weight in gold.

Boats built of fabric stretched over wood make very satisfactory dinghies; but they command a high price when new and are subject to damage from weathering and abrasion. They are easily patched, however, and, although they demand considerable maintenance, often their low price in a second-hand market makes them well worth purchasing for use as tenders. There is, by the way, a new fabric under development which is similar to laminate, or sandwich, construction. This consists of inner and outer skins of tough, elastic material like automobile tire substance, retained by a center layer of more rigid nature. When this product has been fully developed, it will probably make one of the best possible boat skins; it resists abrasion well, is seamless, and unusually strong.

### Metal Construction

The first important use of metal in boat construction took place during the Civil War when the *Monitor* and the *Merrimac* clad themselves in sheet iron armor for protection against one another's gunfire. Early metal construction was mostly a matter of attaching iron plates to the wooden hull. Riveting techniques soon advanced enough so that metal planking could be used directly as watertight attachments to the metal skeleton of the vessel. It was not until the development of the portable welding torch that true metal construction could be used in small craft. Of course, metal sheathing was used as early as the eighteenth century to protect the wood bottoms of boats against attack from worms. However, such protection was in no way structural and even as a protective device was rather ineffective because the larvae of the wood-boring worms often floated between the seams of the copper sheathing and lodged against the surface of the wood.

Metal boats today are generally built of iron or aluminum. In sizes below the tonnage of a harbor tug, iron is a very poor investment. The metal is too heavy for small craft, it requires constant maintenance, is very difficult to repair, and even so simple a project as attaching a cleat to the deck becomes a major operation. Great advances have been made in plating iron to protect it from corrosion. Often this is done with hot zinc, but even this galvanizing is vulnerable to chipping and wear and once it is gone the metal bleeds rust.

Aluminum, on the other hand, has some valid uses in the boating world. Cruising in fresh-water lakes and rivers, aluminum boats will often last a long time. They are quickly and seriously attacked by salt water, however, so that in coastal areas their life is very short. Because aluminum is difficult

to weld without special, artificial atmospheric conditions, aluminum boats are generally fastened with rivets. This type of construction makes a poor appearance, is not inherently strong, and is subject to leaking. The main advantages of the aluminum boat are its light weight and moderate price. These boats are excellent for car-top portage and, for white-water canoeing, the aluminum boat with built-in flotation tanks has become a standard.

Because the grade of aluminum alloy used in boat building is soft and corrodes easily, aluminum boats depreciate quickly in resale value. The boats are also hot to the touch in sunlight and difficult to heat in cold weather.

Electrolysis, which is a state of metal deterioration caused by the electrochemical reaction of metals in salt water, can be a serious problem with metal boats. See Photo 8-1. Electrolytic decay generally takes place between dissimilar metals, even if they are mixed in the same alloy. Thus, if you have electricity on board your metal boat or bronze propeller shafts or bearings, electrolysis becomes a real risk. Metal boats are happiest in fresh water because of this and if you purchase one you may find your resale market is badly curtailed by its limitations to fresh-water areas.

Photo 8-1. Electrolysis attacked this bronze propeller due to faulty electrical grounding of the engine. This was a new propeller two weeks before the photograph was taken.



**Plastic Construction**

Plastic boats include a modest variety of experiments, ranging from resin-impregnated paper to fiberglass-reinforced plastics. These latter, known as FRP, are about the best value for your money obtainable in any type of boat. There are many kinds within the species and in the chapter on "Construction" we shall investigate the advantages and disadvantages of monococque (or single skin) construction, sandwich laminates, and flat sheet laminates. In general, the values of quality fiberglass boats are: no maintenance; no seams; no rot; no worms; color may be molded in; no shrinking or swelling; long life; unusual ease of repair; high strength, if properly designed and built. All these advantages can be summed up in the fact that fiberglass boats are very economical to maintain and have little depreciation in their value for resale.

The chief disadvantage of fiberglass boats lies in the fact that today the market is flooded with the products of many builders. As in any other industry, quite a few of the builders are turning out inferior work. The important things to be wary of in fiberglass boats are pin holes through the resin; hulls with sharp angles, as in hardchine or lapstrake boats of FRP (these sharp angles are focal points for any stress within the boat and are, therefore, easily split, cracked, or punctured—boats with sharp angles or lapstrake boats of FRP should be avoided at all costs); generally flimsy or flexible hulls and decks, without bulkheads and stringers for local stiffening; areas of soft material covered with glass, which are intended to carry heavy loads. These latter areas include transoms. In order to get thickness and resistance to deflection, transoms are often made from a core of cork or honeycomb paper wrapped with fiberglass-reinforced plastic. When the outboard motor is clamped to such a transom it soon destroys the transom's core through its vibrations. When the core yields, the walls of the transom must yield too and the result may be disastrous.

One reason that the top-quality fiberglass boats are such good buys is that the purchaser spends the greater part of his money on the boat itself instead of on the labor which went into assembling it. By contrast, when you purchase a wooden boat, most of your expense is paying for the labor of planing, nailing, caulking, finishing, and painting. The dollars spent for the material itself may amount to only ten per cent of the total cost of the boat. Building in fiberglass will be treated at great length in the "Construction" chapter.

## DESIGN

Before we talk about the actual shapes of hulls, it is important that the boat buyer understands the concept of simplicity. In any boat or equipment, you will always receive the greatest value for your dollars when you pur-

chase the item of the utmost simplicity. Every detail of your boat which is not structural, as the hull and decks are, involves luxury labor and material. Not only must you pay for this, but at resale time the prospective buyer as often as not will have his own ideas about changing the boat, and will be reluctant to pay for them twice. Certainly a boat needs lockers, table surfaces, mirrors, and the like. But such costume jewelry as chrome panels on the topsides, and tail fins aft, are not only evidence of the poorest sort of design; they also cost additional money and, by dating the boat, make it very difficult to sell when fashions change. You will find, as you look at high quality boats, that they have no decoration of any kind. They count instead on their own shape and finish to please the eye. These boats always bring top prices, even when they are very old, and the experienced buyer knows that the money in them went for basic construction.

Dollar for dollar, you will always get the greatest value from the boatbuilder who turns out a limited number of vessels to order and who does not try to compete by flooding the market with very cheap boats. Whether in wood or fiberglass, the mass-produced boat will have so many markups by the time it reaches the showroom floor that the potential buyer would do better to put the extra money into the boat while it is still in the builder's yard.

The shape of a boat influences both its comfort and seaworthiness, as well as its actual strength. In power boats and some centerboard sailboats, the v bottom affords great stability and makes for a strong structure. In sailing craft, which all operate at low speeds, the v bottom, while satisfactory, is not as fast as the wine glass or rounded section. In auxiliary sailboats, and auxiliaries, the combination of shallow draft with some outside ballast and a centerboard seems to be the most desirable design. The centerboard provides the lateral resistance necessary for proper performance under sail, but it offers little draft when you are exploring or grinding home under power and want to reduce all drag. A properly designed centerboard is located so that it also works as a trim tab does on an airplane, neutralizing the drag upon the helm so as to make the boat self-steering. Actually, of course, the centerboard provides a movable pivot point about which the forces on the sails of the boat and the forces of the boat against the water balance one another out. By shifting this pivot point you can put the boat in a state approaching dynamic equilibrium so that the slightest touch upon the helm will affect her immediately. This advantage of the centerboard boat is so important that many of the Class J boats which raced for the America's Cup installed boards for just this purpose.

In any boat, the most desirable bow will be rather long, and shaped in section like a rounded v. The bow should lead gently backward, so that the greatest beam of the boat is quite far aft. Under power or sail,



the stern is most efficient when it leaves the water cleanly. This means it should not tuck up in any short curves. For motorboats, the stern is best when it has little or no draft, and ends quite vertical to the water. A number of sterns are on the market which slope in toward the boat at the top. These are of very poor design and can be quite dangerous when running before a choppy sea. Overtaking waves may climb up such a stern and flood the boat before you can regain control. These sterns were developed to circumvent a particular racing rule for sailboats. Their use is justified only when such a specialized boat is in the hands of an expert crew. A double-ended or canoe-stern boat can be very seaworthy at low speeds but in the sizes much below forty feet makes for a boat that is hard to steer when under sail because of her extreme curvature. Such a boat will also settle badly, aft, when there are several people in the cockpit.

The rarest and most important virtue of any boat is usable deck space. This means that you should have a good, nonskid platform forward to which you can readily get, even in rough water, and a comfortable cockpit where the helmsman can also run the boat. If you are really interested in enjoying your boat be certain that you have an accessible forward deck for handling anchors and lines.

## ENGINES

Although an entire chapter will be devoted to a detailed discussion of engines, it's important for us to review them here for a moment to help you in choosing your boat. We can first divide engines into Diesel and gasoline, then subdivide them into inboard and outboard.

### Diesel Engines

In broad, general terms, Diesel engines are most valuable in heavy-duty vessels that run their power plants for a great many hours. There are two reasons for this: these oil-burning engines are very heavy for their torque, or power, so that unless the boat is big enough to carry their weight, plus the weight of fuel, the engine will be devoting a lot of its energy to propelling *itself* in relation to the total weight of engine, fuel, and boat. Secondly, these engines are expensive to begin with, and often the difference in price between gasoline engines and Diesels will buy more than enough gasoline to make all things equal. Another important observation is that there are different grades of fuel for Diesels and it is not always possible to find the proper fuel in every port.

The advantages of the Diesels are that they are very simple, mechanically; they are not subject to failure from electrical mishaps; and there is almost no explosion risk. With one exception, all Diesels have so far been developed for inboard power. The one Diesel outboard (at the time of this writing) is still experimental.

**Gasoline Engines**

Gasoline engines are very dependable and are available with magneto double ignition systems so that failure is virtually eliminated. For inboard power, the Palmer Engine Company of Cos Cob, Connecticut, makes the I H series which use the International Harvester tractor block. International Harvester tractors are truly international and since their blocks and parts are standardized this means that with a Palmer engine you can obtain parts for your boat anywhere in the world. Wherever there is a tractor dealer you can be sure you can get proper sized replacements of such important parts as oil filters, distributor caps, and crank shaft bearings. The Palmer is also the simplest, most dependable engine I have ever seen. In buying or selecting an engine the most important thing to watch out for is whether or not the manufacturer is still active in business. Recently, a number of important brand engines have been discontinued by their manufacturers. Nonetheless, such engines are still on the market through dealers. Even though these machines are new their resale value is questionable and parts may be almost impossible to obtain.

*Outboard and Inboard Motors*

It is so difficult to compare outboard and inboard motors that we shall have to limit ourselves to the most salient points in this chapter. The outboard engine is no novelty. It has proven itself thoroughly as a useful power plant. Here are the things that make the outboard motor desirable: compactness; minimal fire danger and explosion risk; readily available parts and repairs; the fact that while your engine is under repair you can rent a quickly installed substitute for it and not miss any of your boating times; the engine is easily removed from the boat for storage, protection, and overhaul.

Despite the high popularity of the outboard it has some very real disadvantages. These are: noise; high fuel consumption; short life span; high initial cost and depreciation; very inefficient operation because of the propeller location (see "Engine" chapter); high center of gravity, plus great weight located far aft in the boat, making an inherently unstable installation; inability to maintain self-steering with one engine; vulnerability to wave and weather damage; it is difficult to repair with ordinary tools; it has dangerous handling characteristics in rough weather. This last fault results from the fact that in really rough weather conditions any boat must slow down. When the outboard, with its rudderless, far-aft propeller, is slowed, it has a yawing tendency that can easily result in broaching and capsizing the boat.

In contrast to the outboard, the inboard engine has its weight well distributed and this weight adds to the stability of the boat. The engine is



protected from waves and weather, uses very little fuel for its power, and, if it is 4-cycle, will last for a long time. Thrust from the propeller works against the rudder, which gives good control while steering at all speeds. Also, the inboard has a moderate initial cost and slow depreciation. Finally, the engine has a low noise and vibration level, can be repaired and adjusted with ordinary tools, and is capable of developing its power at reasonably low speeds.

The inboard disadvantages are these: the boat must be laid up when the engine needs repair; the engine requires packing glands to be installed through the bottom of the boat to keep water from entering around the propeller shaft; there is some fire and explosion danger if the engine is not properly installed and adequately cared for.

In any engine, the desirable characteristics are low piston speed (this speed should be less than one thousand feet per minute for a long engine life), standardized replacement parts (which precludes foreign engines at this time), and, in multiengine boats, opposing rotation of the propellers. Propellers are most efficient when their bottom blades turn toward one another and this manner of installation also makes the boat more easy to steer than when the rotation of both blades is the same.

The problem of corrosion among dissimilar metals in an electrolytic solution of water is a major handicap in the construction of metal boats. This is the condition we referred to as "electrolysis." It is more serious than ordinary rusting and corroding and often takes place so subtly that it is difficult to detect until the metal is weakened seriously. The ability of one metal to attack another in an electrolytic solution is a measure of the attacking metal's "nobility."

Here is a table of metals, ordinarily used in boat construction, arranged in order of their nobility. Each metal in the table is capable of attacking any or all of the metals listed below it. Except under forced conditions which do not occur in nature no metal in this table will attack any metal listed above it.

Table of Electrolytic Activity

| | |
|---|---|
| 1. Gold | 8. Cadmium |
| 2. Mercury | 9. Iron |
| 3. Copper | 10. Chromium |
| 4. Antimony | 11. Zinc |
| 5. Lead | 12. Manganese |
| 6. Tin | 13. Aluminum |
| 7. Nickel | 14. Magnesium |

Metal-hulled boats, even though they are intended for fresh-water use, should not mix metals. The notable exceptions are zinc galvanizing on iron, magnesium fastenings with aluminum, and some alloys of brass and bronze

which we will discuss separately. In nonmetal boats, the problem is a bit more general. The best metals for fastenings or for fittings are Monel and the phosphor or silicon bronzes. They are not attacked by electrolysis, are easy to work with, and are of extremely high strength.

One of the factors involved in the electrolytic reaction among metals is the relative mass of each metal in the solution. For example, in a boat with an iron ballast keel, it is perfectly satisfactory to use bronze bolts and fastenings because, although these will attack the iron over a period of time, they have so little mass and surface in relation to the iron that they eat it away at a very slow rate. Beware, however, of iron keels with iron or stainless steel fastenings when bronze propellers, shafts, or hull fittings are present. The same rule applies to lead ballast keels with iron or stainless steel bolts. Electrolysis is certain to come. Galvanized iron fastenings are excellent in boats so long as a large mass of bronze is not present. Cadmium-plated iron is completely unsatisfactory immersed in salt water, although it has some special uses we will discuss under "Rigging." Many people think of brass as a boating metal, but it is entirely useless below the water line. Even in fresh water there is electrolytic danger, while, in salt water, brass, which is an alloy of copper and zinc, will actually attack itself and break down although it is not in the presence of other metals. Stainless steel, too, will eat away in salt water so that its primary use is limited to rigging wire, where it must be replaced after three to six years of continuous service. Copper is often used to rivet wooden boats. Although this is not dangerous from a corrosion standpoint, copper is very soft and sometimes will stretch or deflect and the boat will develop leaks.

## WOODS

While the proper place for woods is in the chapter on "Construction," we will look briefly at the general types used in boatbuilding. Cedar is the finest wood for boats and the Spanish, or Port Orford, cedars not only seem the best but also resist rot rather well. Fir, if well seasoned, is very strong and makes fine planking. Yellow pine is almost rot proof and, if good clean wood is used, makes excellent underwater planking. Cypress, common in many parts of the South, is tough and resistant to rot. Almost all the mahogany varieties are good, but Philippine mahogany is the least desirable because its quality varies over a great range. Unfortunately, Philippine mahogany is the most common mahogany of all. However, if select pieces are used, it is quite suitable for boatbuilding. Teak, today, is so expensive that we shall consider it only for trim. It makes the finest trim of all, needing no upkeep and being stable and quite rot resistant. Oak, long synonymous with boatbuilding, is excellent when seasoned but is subject to rot. For spars, spruce is the lightest, strongest wood and fir is a good runner-up, although it is half again as heavy as spruce.



In the "Appendix" at the end of the book is a list of woods and their qualities.

## DIAGNOSTIC CHECK LIST

Now that we have provided ourselves with the background necessary for selecting a boat, it is useful to organize a check list of points which should be specifically examined in a prospective purchase.

1. Look at the general external appearance of the boat, noting particularly blistered or heavy cracked paint on decks, spars, topside and bottom. Probe these places for soft spots, using a dull penknife blade, and holding the blade at right angles to the grain of the wood. Easy penetration of the wood usually means that there is rot present. Small, local areas of rot away from the stem, keel or stern of the boat are easily repaired. Elsewhere, rot is costly and dangerous.

2. Continuously varying your line of sight, scan the boat for planks which seem sprung out from the rest of the hull, especially below water line. This symptom can be indicative of rot (check as above) but may more likely be a late sign of electrolysis as a result of which fastenings have been destroyed. If you're really interested in the boat, you will have to dig out several fastenings in different locations and check them for rust or for the pale, salmon pink, sickly color which is symptomatic of electrolytic attack. Unless the boat is altogether desirable in every other respect, however, you should abandon it as soon as you detect such a plank.

3. Sight along the sheer line of the boat on both sides, first checking from the bow looking toward the stern, then in the opposite direction, keeping the eye always at sheer level or below. Any sign of waviness or irregularity is a bad symptom. The sheer should be a fair continuous curve. Waves and irregularities in the sheer mean that the boat has changed shape because fastenings have slipped due to rot or electrolysis, or the structural material itself has sagged, stretched, or warped. In any case, this symptom means that the boat is now weak and that the condition can no longer be repaired.

4. Examine the seams in the planking for regular, uniform fit. Any gross mismatching of planks indicates a poor construction or repair job, which you must check very closely because it may hide other disrepair.

5. Check the propeller, propeller shaft, bearings, rudder, struts, keel and keel bolts for signs of electrolysis. This condition may show itself as pitting, ragged edges, lacelike eating-away of metal, salmon pink discoloration, or cheesy deposits of corrosion salt. Unless the boat is excellent in every other respect, give it up at the first sign of electrolysis.

6. Examine the hull minutely for pinholes. Even in fiberglass or metal boats this means trouble. Write off the boat at once. In wooden boats,

pinholes are made by worms. A tiny hole in the exterior of the wood is usually the entry to a fantastic honeycomb interior left by the boring action of the worm as it progresses along the planking. A single such pinhole may require replacing an entire plank. Again, write off the boat. One exception to this rule is the worm shoe, a strip of wood along the bottom of keel and rudder which is added to the boat as a chafe preventer in grounding, and which, if separated from the boat by tar or roofing paper, will not let worms pass through into the hull. Look for these pinholes particularly in the deadwood area. This is that section of the boat forward of the rudder post and extending between the hull and the ballast keel. Because it is difficult to use antifouling paint behind the rudder post, worms often enter here and along the entire edge of the rudder itself. Another place to check for wormholes is in the area enclosed by the grill of the through-hull plumbing fittings. You must inspect in here with the aid of a light because this is an area particularly hard to keep worm free. This is also a good time to check the hull fitting itself for electrolysis.

7. When the spars are out of the boat, check the foot and head of the masts for rot, paying particular attention to areas around chafing patches, mast fittings, spreader ends and sockets, and the clevis, or bee hole, where the halliard goes through the mast. Also, check for dried-out glue joints on the spars, and rot under boom and spinnaker pole fittings. Booms, masts and spinnaker poles are easily repaired if the boat is otherwise sound.

8. Examine the rigging for rust and broken wires. This will generally occur most at the terminals of the wire. Salt water lodging in the terminal sockets causes rust which expands and may rupture the sockets with hairline breaks. Remember that stainless steel wire is only stain resistant; it, like any steel, can rust. If the wire is six years old or more it must be replaced. If it is frayed or rusted, don't take a chance on it even though it may be younger.

9. Lower the centerboard as far as you can and check for wormholes. While the board is down, examine the attachment of the pennant which raises and lowers it to make sure that this is sound.

10. Check for rot and softness on the mast step, the floor timbers, the stem and stern posts at their top and bottom, the tops and bottoms of the frames (if they fit into mortises in the keel, they are likely to have rotted) and the deck beams, both at their ends and on the surfaces in contact with the deck itself. To do this you must probe along the edges of the beams. Also examine the clamp and shelf, the base of the centerboard trunk and its trunk logs. Check the ends and bottom of the engine bed for rot and loose fastenings. One or two isolated cases of rot in these areas can be easily repaired or replaced. Rot in the stem or transom area is repairable but is a much more serious proposition.



11. If possible, look behind the icebox for rot. This area, and the wood in the bilges where the icebox may drain or drip, are notorious for rot. If you can't tell from inside the boat, go back outside her and probe the planking at the seams with your knife, searching the area behind the icebox from deck to keel.

12. In fiberglass boats, examine everywhere for areas that look unsaturated by resin, show coarse texture, or have pinholes. Often these pinholes are best seen from inside the boat where dots of sunlight will shine through. Resin-starved areas are most prevalent in the stem, chine, angles of the cabin and deck, engine beds, stringers, and bulkheads. They indicate poor craftsmanship, structural weakness, and a boat that will leak. If pinholes are present, reject the boat at once.

13. Walk on the deck, stamping heavily to see if it is stiff. If it yields readily, the boat is weak. This is especially true because the deck is a vital structural member. On wood boats with fabric-covered decks, look for blistering or breaking of the fabrics and for holes. If fresh water enters these areas it will cause rot. Also, check the hole in the deck that forms the mast partners. This is a likely place for rot because fresh water funneled down the sail and the mast can collect here. All of these areas and conditions of rot can be fixed, not by repairing them, but only by replacing them, an extensive operation. Serious rot also occurs commonly along the juncture of the cabin and the deck and repair here requires major carpentry.

14. Outside the boat again, shake the rudder and the propeller as hard as you are able. If they yield, either the boat is weak, the fastenings are gone, or there is rot behind their fittings. None of these are easy to repair. Often there are cracked planks, drains, or stringers in this area and far forward. These repairs are simple and inexpensive and will not seriously affect the value of an otherwise good boat.

15. Finally, examine the deck fittings, chain plates, engine, and other metal work for exterior signs of deterioration. For obvious reasons that we won't go into now, you will subject these parts to a more rigorous inspection when you test the boat, as we shall describe in Chapter 2. Broken, worn, or ancient deck hardware is not difficult to replace and we shall show you how to accomplish this quite inexpensively. A badly decayed engine, however, is something quite different. You can plan on replacing it immediately when you estimate the cost of a secondhand boat with such an engine.

## EQUIPMENT

Normally included in the selling price of a typical cruising boat are its sails, mattresses, cushions, china, cooking utensils and stove, navigation lights, batteries, two fire extinguishers, life jackets, anchor and anchor

line, compass, and a permanently installed bilge pump. While the disposition of this equipment is entirely up to the owner of the boat, you should ask him if these items come with it. If they do not, it is of little consequence; nor should you be overly influenced in favor of a boat because its sale includes a great assortment of "extras." There is little point in dickering over five dollars' worth of silverware in a several thousand dollar purchase.

Boat hooks, fenders, dinghies, linen, clocks, barometers, and similar gear are only chance acquisitions. Too many extras may be a cover up for some deficiency in the boat itself. Be certain to check any boat over sixteen feet which has any sort of motor to see that her registration papers or documents are aboard. You can also verify the age, builder, and ownership from these papers. Find out who is the boat's insurer, and whether or not the policy is up to date. This may save you money later because the insurance firm generally would not have issued a policy if the boat appeared structurally unsound.

When you have done the best job you can in evaluating a boat, take her out and test her along the lines described in Chapter 2. After that, if you like her, buy her. Your own judgment will be the safest judgment to trust.

CHAPTER 2

# Testing the Boat

WHEN A GENERAL INSPECTION and structural survey, as outlined in Chapter 1, have narrowed your choice of boats to one or two serious prospects, a brief trial run in each boat will provide you with the final clues for making your selection. These tests are applicable to boats of any size, new or used. For each boat, these test runs will evaluate seaworthiness, seakindliness, construction characteristics, and general overall performance. Let's define these terms first, to help us with the tests.

## DEFINITIONS OF TERMS

*Seaworthiness* is the ability of a boat to survive dangerous sea conditions. More, it is the ability of a boat not only to stand up to such conditions but to be driven against them. Of course, these terms are not absolute—an orange crate will readily ride out a storm that could cripple a huge liner, while an ocean-racing sailboat can go where an outboard cruiser fears to tread. For our purposes, whether we sail on inland lakes or upon the open sea, we have a right to expect any cruising boat to be noncapsizable, to have watertight hatches so that she can be left to her own devices in any emergency, and to have a self-bailing cockpit which discharges its water overboard instead of draining it into the bilge.

In structural terms of seaworthiness, the cruiser should be designed so that it will provide ample air to its engine in any weather, but it is vital that the air be supplied through a system of baffles that will prevent water

from drowning the electrical system. Engine failure, resulting from wetting out of the wires, can cripple the boat for long periods of time and can be altogether dangerous if sparks begin to jump about, because there are always some gas fumes present in the engine room. Finally, construction of the boat must be strong enough to stand any abuse from the sea when the vessel is being operated at reasonable speeds in heavy weather.

*Seakindliness* is a direct consequence of the designer's art. This is a term which describes the boat's reaction to the sea, her smoothness in recovering from a roll, her ability to cushion waves so that she will not pound. It is a concept as evasive of measurement as beauty, but no less real, because one of the main functions of a pleasure boat is to stand between the weather and her crew.

*Construction characteristics* concerning us in these tests include the watertight integrity of the hull, decks, and superstructure, the sturdiness of fittings and equipment, the stiffness of the rig and engine beds and the extent to which the entire boat resists changing its shape when it is in action upon the waves.

*Performance,* or handling qualities of a boat, include the exactness with which the operations of the helmsman are carried out by the boat and its machinery. Time lag, for example, is an undesirable quality. Delay in response between the helmsman and the boat often occurs in steering or in engine-control manipulation to the point where, beyond its inconvenience, it is dangerous. The efficiency of the engine, propeller, rig and sails and the simplicity with which they can be used fall into this category.

It is most important that you make the test run with another person on board, preferably the owner or a certified agent. This is essential from the standpoint of safety and as legal protection for you in the event of any mishap. If the owner cannot come with you, have him write you a note granting you permission to test his boat. Discuss his insurance with him, making certain that the boat is not technically laid up or otherwise liable to forfeit her insurance rights. Under some insurance policies the boat must be inactive for at least six months out of every year and this time may be accumulated in such a way that the day you choose to test the boat could be one on which it is not insured. If you find that the boat is not protected, take out a one-day policy in your own name, covering that particular boat. This policy should also provide protection for damage done to people and property while you are testing. Such security is the cheapest peace of mind that you can buy. Lawsuits come from many strange directions, and even boating folk are not immune.

Next, be sure that the boat has been in the water long enough so that all the wood is completely swollen. This qualification can be overlooked, of course, in boats built of metal or fiberglass. Swelling is important, and not only because it shows you where the boat leaks. Remember that the planking of the boat is held to the frame only by its fastenings. Until all the wood has swollen and the seams throughout the boat are tight, each plank and frame and beam is free to work past its adjacent members. This movement of the parts puts extra loads upon each fastening, and, moreover, spaces are left between the structural members of the boat in which dirt may accumulate and pack. The building up of debris in these spaces creates what may be described as many tiny fulcrums. When this happens, each piece of wood becomes a lever capable of exerting tremendous force against its fastenings as the parts work back and forth across the fulcrum. Once swelling of the wood is completed, face-to-face contacts among all parts are firm and uniform. Then, all the pieces of the boat assist one another to retain their proper position and the net effect is a strong continuous structure.



Finally, before starting the test run, check your equipment. Be certain that the boat has enough life preservers for everyone aboard. See that at least two full fire extinguishers are within easy reach. Now, put your head right into the engine room and sniff the air in it and in the bilges for the smell of oil and fuel. If you detect any such smell, pump the bilges dry and ventilate the boat until it has altogether disappeared. In any case, pump the bilge bone dry and sponge up every last drop of water. Place some dry rags underneath the propeller-shaft stuffing boxes. Close all the hatches and fill the fuel tanks to their tops. Bring the oil level up to its full mark with clean oil. Fill the water tanks right up to their caps. Now, before closing the main electrical switch, sniff again for gas fumes and look about the tanks and engine room with a flashlight for any sign of leakage. Stow your tool kit where you can find it easily and quickly. It should contain an insulated screwdriver, a ball-peen hammer, an adjustable crescent wrench, a scrap of fine sandpaper (be sure to use sandpaper and not emery cloth) and a pair of wire cutting pliers.

### Testing the Ignition

When everything is in readiness, close the main switch and look at the ammeter. Because the ignition switch is still open, the ammeter should read zero. If the needle shows discharge, current is leaking. The same is true if it indicates charge, with the extra complication of some reversed wiring that will have to be corrected. This deflection of the ammeter is a real danger sign. It means that for an unknown length of time, whenever the main switch has been closed, an environment has been set up in the boat which favors electrolysis. Such electrolysis is often first evident in the fittings associated with the ground wire of the battery circuit. For example, if the circuit grounds to the engine, the final discharge of electricity into salt or fresh water may be at the propeller blades, the propeller-shaft tip, or the water fittings which pass through the hull to carry intake water to the

engine. The ground wire may lead to a keel bolt and the bolt itself may start to corrode. In the case of an iron ballast keel held to the hull with bronze bolts, the bronze will lead the current to the iron, gradually enlarging the hole around the bolt. This latter eating away of material generally takes place very slowly, inasmuch as the mass of the iron is enormous in proportion to the mass of the bronze.

### Starting the Engine

Assuming the ammeter reading to be zero, you are now ready to start the engine. Try the throttle to be sure that it is free, then set it at such a position that it is almost closed. If the boat has more than one engine be sure that the one you choose to start first has a generator attached to it. This assures you that you can replenish the batteries quickly. When the engine is running smoothly at its lowest r.p.m., have your assistant check the carburetor with his flashlight to be sure no gas leaks have occurred since starting. Have him play the beam of his light along the fuel line to the tanks, checking couplings and bends for loss of gas. While he does this, walk aft and look at the exhaust. It should be almost odorless, steamy white, and a generous flow of water should be pulsing from the exhaust pipe. If the water flow is weak or has stopped, have your companion turn the water-pump grease cups down until they stop. If water still doesn't flow and you know that the intake valve is open, stop the engine at once. Stoppage of cooling water through the engine can be caused by marine growth in the through-hull fitting, a broken pipe in the water system, a worn out water pump, an unlubricated water pump, a clogged water filter or deionizer, a water filter or deionizer located too high above the water line and, as a result of any of these, entrapped air, or, at the very worst, occluded engine passages may be the difficulty.

Water lines that have been fouled by barnacles and grass are easily cleaned out with a plumber's snake. Water pump replacements are more expensive; a new pump for a twenty-five horsepower engine might cost twenty-five dollars. However, you can install it easily yourself. A clogged filter or deionizer is cured by simple hand labor; air entrapment is corrected by lowering the offending unit until it is below the waterline. Occluded engine passages require brute force treatment. The engine must be opened up, head, manifold and block, and the salts or debris which have accumulated must be removed from the passages by tapping a stiff metal rod through all the water cooling holes. This treatment involves the possibility of tapping the rod all the way through a badly corroded cylinder wall, but, more important, it is the sign of an old engine which may soon have to be replaced.

If the exhaust shows a generous flow of cooling water, watch the engine temperature gauge for danger signs in another direction. It is a common boast among boat engine owners that some particular machine runs cool enough to touch. This is the worst thing it could do, because an engine running at a temperature of 100° F. wears out about eight times more quickly than one running at 180° F. If the boat you are testing has been running very cool for very long, its friction surfaces are probably in bad shape. We can tell something about this from the exhaust now, and, later, from the oil level. A gasoline engine burning excess oil will show a blue-gray exhaust which carries a strong oil smell. In order for that oil to be in the exhaust, it had first to pass by the valves or piston rings or both. In any event, the fact that it got past indicates wear. Not only must you correct this wear, so that the boat doesn't break down in hazardous conditions, but you should suspect from these symptoms that other parts of the engine are approaching a similar state of disrepair.



If the engine has survived our criticism through the preceding paragraphs, it should now be warm enough to use. Still at idling speed, with the boat secure to the dock or mooring, ease the reverse gear lever of the engine into forward and reverse positions. The gears should shift smoothly, locking into each position with a distinct click. Watch the tachometer as you do this, observing that the drop in r.p.m. does not exceed about 100 revolutions. When the boat is in gear, listen for the squeal which means a poorly lined-up shaft. Notice whether or not the boat vibrates appreciably in gear, another symptom of misalignment and also an indication of incorrect distributor or magneto timing, or of frozen valves. If the engine simply dies, the carburetor mixture may be poor, or the idling adjustment may be set too slow. None of these is serious, although a broken valve may take much time to replace. This is a job which you can do yourself. A mechanic will have to charge you about fifty dollars, simply because it takes time to reach the valve. If you have the time and interest, you can purchase a valve for a dollar or so. The engine trouble-shooting section of this book will discuss all these symptoms in more detail.

With the gears in neutral again, observe the oil-pressure gauge. It is important that the engine is warm before checking this pressure, although the gauge should show some pressure within half a minute after starting. Now, with the oil flowing easily, pressure reading should be checked against the recommendation in the engine manual. Remember that the oil pressure gauge measures pressure only, not quantity or adequacy. Too high a pressure means that something is blocking the flow of oil, and this obstruction is generally due either to a dirty oil filter or to rust, carbon, or congealed oil in the line. When the oil pressure is too low, it suggests that the oil pump is worn, that a leak exists in the oil line, that there is dirt between the engine and the gauge, or that the gauge itself is damaged. Gradually increase the engine speed to about one-quarter throttle. If the gauge needle climbs smoothly with the change in speed and returns

smoothly to idling pressure when you close the throttle, the gauge and the pressure system both are in good shape. Erratic action of the gauge or failure of the needle to return to zero when the engine is stopped are indications of trouble within the gauge itself. Check the gauge by uncoupling it from the oil line, wiping the excess oil from the nipple and alternately blowing and sucking on it several times. If the symptoms persist, the diagnosis of gauge trouble is confirmed. If the symptoms do not show when you apply this test, the gauge must be given a clean bill of health and the trouble sought for in the engine itself.

With the engine still idling, put the boat in forward gear again and alternately turn the rudder to port and starboard. Station your assistant in the stern to see that the wake of the boat is deflected by the rudder when you turn the wheel. If the rudder responds, everything is all right and you are now ready to get under way.

## The Test Run

We're going to conduct these tests in open water, well clear of any boats or swimmers. You will have to avoid any place which has a noticeable current because you'll want your attention free to study the boat without distraction from obstacles or navigation. As soon as conditions permit, speed the boat up to its cruising r.p.m. and note the time. Cruising r.p.m. for most engines means running at three-quarter throttle and you can use this as a guide if there is no engine manual aboard to suggest a proper speed. The reason for noting the time is that you are going to check your fuel consumption throughout the test period and it is safe to assume that you burn an insignificant amount of gas during the warm up test. On your way to the test area, have your companion look at the exhaust from time to time, noting any blueness in the smoke or loss of flow of the cooling water from the engine. At any one of these danger signs, slow the engine down to idling speed and return immediately to the harbor.

### *Trim*

By having an observer on board you will be free to give your attention to the more subtle characteristics of the boat. First, notice the angle at which she rides. A well-designed boat in proper trim, fitted with the proper engines and propellers, will ride quite level, her bow just barely lifted above the water. If the bow is high when the boat is under way, so that it assumes the attitude of a surfboard, the boat is altogether inefficient. This is true for several reasons.

First, the boat no longer presents a sharp bow to deflect the water but, instead, tries to shove it ahead much as a snow plow does. Next, when the bow is high above the water, it automatically means that the stern is lower than normal, pushed down by the total weight of the boat instead of only by a portion of that weight. This bow-high attitude under way can be due to poor design, poor ballasting, wrong propellers or wrong propeller location. We can check each one of these things in turn.



Have your assistant go all the way to the bow of the boat. If this relocation of his weight brings the hull to normal trim, your problem is easily solved by restowing ballast. If his weight up forward has no correcting effect at cruising speed, open the engine to full throttle, a little at a time. In the majority of boats, the propeller shaft slants slightly downward as it goes aft so that the blast from the propeller has some tendency to raise the stern. At full throttle, this blast is rather strong. If it takes all of this force to level out the hull when underway, the stern is poorly designed. If, however, the boat begins to level out at a slight increase in throttle, a propeller change may be all that's necessary to turn the trick. We can pin this down more exactly.

If, at full throttle, the bow climbs even higher than before, the boat is of poor design and there is little you can do about it. On the other hand, if a slight increase in throttle, for example, one or two hundred r.p.m., brings the hull to level trim, then a slight increase in propeller pitch (in the neighborhood of one-quarter or one-half inch) will turn the trick. This pitch variation can be done only by a propeller specialist. It is quite inexpensive, five or ten dollars at the most, and will often make a strong change in the performance characteristics of the boat. If it is impossible to change the pitch of the propeller because of engine loading, perhaps you can shorten the propeller shaft and gain a few inches of additional space between the propeller and the stern of the boat. This decreases the amount of water which escapes upward from the propeller, leaving a cavity into which the stern of the boat tends to sink.

There is another sign of inefficiency called the "rooster tail." This is a spectacular demonstration of high, far-flung sprays of water starting at the transom of the boat and arching back through the air along the wake. The rooster tail ordinarily occurs only at high throttle, but at any time it is a bad sign. A propeller-driven boat moves forward in proportion to the amount of water driven astern. This is one of the fundamental laws of physics which, more accurately stated, says that every action has an equal and opposite reaction. Because of this, any water which escapes upward from the propeller does not contribute to the forward motion of the boat. Instead, it merely represents power lost through waste. What we want for efficiency is to thrust the maximum amount of water aft. The solution to this problem may lie in propeller alteration. The cheapest first experiment is to increase the pitch of the propeller blades and then to rotate the propeller more slowly. By increasing the pitch, we take a bigger bite of water and, by reducing the speed of rotation, give it less chance to escape

from centrifugal force. This is simple to do with low speed engines, but engines which have been designed to turn at a high r.p.m. may overheat or develop problems in carburetion and in their generators if they are made to turn below normal speeds. An alternate move is to relocate the propeller further forward, under the stern, so that the expanse of boat above it acts to flatten the blast and helps drive the propeller stream aft.

The blast from the propeller is called its "slipstream," and is different from the actual slipping of the propeller in the water. When a propeller rotates at such a speed that it simply churns up the water through which it is moving instead of driving it aft, the propeller is said to be "cavitating." This is an extremely inefficient condition and a costly one; cavitation causes the propeller blades to pit and this pitting, in turn, increases cavitation. The end of this vicious circle is generally a broken propeller blade, often under the extra load which comes when you drive your engine hard in bad conditions. You can most easily recognize cavitation by the whirlpools and turmoil right above the wake of the boat at the transom. Moreover, there is a sucking, throbbing sound in contrast to the smooth gentle vibration of proper propeller action.

*Vibration*

The next thing to look for in a boat is vibration. At cruising speed the boat should be a quiet machine. While the sound of the engine exhaust may be objectionable, the noises we are really interested in come from the boat itself. First, you must eliminate all movable offenders. That is, be sure that the locker doors are closed, drawers, cupboards and table leaves secured. See that the dishes, the glasses and galley gear are not making sounds. If the hull itself vibrates, with bulkheads, decks, berths and instrument panel all in chorus, the construction of the boat is inadequate for the amount of power which it has.

Another source of vibration and noise may be the engine itself. This is most often the result of backpressure on the exhaust-pipe opening. If the exhausts are too close to the water on a low speedboat, backpressure again results. Here, the settling of the transom under way forces the gases against a pressure head of water. This condition shows itself to the eye at once—the exhausts are out of sight beneath the wake—and to the ear by a rumbling, irregular exhaust sound. Sometimes trimming the boat will solve the problem. Putting some ballast forward or removing weight from aft will bring the exhaust pipes clear of the surface of the water. More often, however, the only answer lies in relocating the pipe.

Another source of underwater vibration is backlash. This may occur in forward gear or in reverse. It is caused by the blast from the propeller impinging on an overly thick deadwood or rudder blade. The answer lies in tapering both the deadwood and the blade of the rudder, if possible. If, for



structural reasons, this fairing can't be done, changing to a propeller which has one more blade will often help, although you will still lose a good part of your thrust from the obstruction caused by the thick part of the boat. All you gain by increasing the number of propeller blades is to make the delivery of the water which is driven aft more nearly continuous, while reducing the amount of water which must be handled by each blade.

Vibration is serious, always. When Joshua stormed the walls of Jericho he destroyed them with sound. The principles of physics haven't changed since Joshua's day, and a high frequency hum is just as effective on plywood, teak, or fiberglass as it was on stone walls. Some answers to the vibration problem might lie in running your boat at lower speeds, using larger propellers or propellers with more blades, or buying a better boat. Unfortunately, intense tests over short periods of time are not nearly so valid as less intense tests which last for several years. Many failures of material have been blamed on accident or on workmanship when the real culprit was sound. In general, vibration problems occur most often in high-speed boats. The manufacturer's popularity is rarely any clue to vibration characteristics when the boat is only a few years old. Quietness and your own good sense are better guarantees.

By now we've probably arrived at open water for our tests. Here, we're going to examine the seaworthiness and seakindly characteristics of the boat. If it has a flying bridge, go aloft with your companion. In any case, have him hold himself securely and turn to watch the wake.

**Beginning the Test**

At full cruising speed, put the boat into a gradually increasing turn in any direction. The wake should appear right at the centerline of the transom. The boat should heel inboard on the turn. If the wake seems to come from the port side of the stern when the boat is turning left, or from the starboard side when the boat is turning right, the stern is skidding. This means that either the bow is digging in or that there is insufficient lateral resistance aft. Have your assistant look at the bow; if it still is riding at the surface, the resistance of the skeg, deadwood, or rudder is inadequate. This can be easily corrected with a minimum of carpentry. If the bow digs in, the boat is unseaworthy and is susceptible to being "tripped" in a following sea. A following sea is one which comes at the boat from astern and sometimes it is capable of delivering quite a push. The result is a snakelike motion of the boat known as "yawing," and the combination of yawing and tripping when they are carried to their extreme is called "broaching." Here is what happens when a boat broaches: a wave overtaking the boat from astern shoves the stern to one side. The bow, digging into the water, becomes a pivot point about which the rest of the hull is pushed. Broaching in heavy weather or in an inlet where the waves are large

can put the boat in a broadside position to the sea, which may roll her over. Short of major redesign and reconstruction, there is little that can be done about too deep a bow. You would be far wiser to look for another boat.

There is another circumstance which can make a boat skid when she turns. Remember how in Chapter 1 we noticed, in choosing a boat, that the propellers of a twin-screw motorboat should rotate in opposite directions with the bottom blades approaching one another in normal, or forward, gear. We observed that the reason behind this kind of installation is that the bottom propeller blade works in denser water than does the top blade. In a boat where both blades rotate in the same direction, the bottom blades add their side thrust to one another, shoving the stern in the opposite direction with much greater power than do the upper blades. We can check for this most easily by noting the direction in which the shafts rotate, but a second, rapid check, to remind us, is to swing the boat in alternate turns port and starboard. If the stern skids more in one direction than in another, this difference in the thrust of the blades is the cause. The solution is to change one engine, or to change the gear box on one side. This, however, is expensive and also involves the purchase of a new propeller for the engine that you have corrected.

When you first put the boat into a turn at cruising speed, you noticed whether or not she heeled inward on the turn. This means that when the boat is swinging to the left she should heel toward the left, and, of course, the same applies to the right. Heeling is a measure of stability. When we tie a weight to a string, and swing the weight about us in a horizontal plane, centrifugal force tries to carry this weight outward against the pull of the string. In turning our boat, the same force works against the hull. In a well-designed and properly ballasted hull, the greatest weight is low—the lower it is, the better the design. Now we can think of each level of our boat as a sort of weight tied to a string. If the low parts of the hull are heavier than the cabin and the decks, they will pull outward with greater force than these higher, lighter parts. As long as the beam and length and cross-sectional shape of the hull are properly designed, these forces will be in equilibrium at any speed with which the designed power plant can drive the boat.

### *Stability*

Every boat must have plenty of reserve stability so that, if it is struck by a large wave while heeled in a turn, it is not capsized or rolled completely over. Whether the boat is sail or power, we can make some guesses about its stability by a simple test. This test should only be given to boats that heel inboard; if the boat you're testing rolls outward in its turn, its stability is dangerously low. It can often be corrected by ballasting,



but the proper correction, which demands reconstruction, to lighten the topsides and cabin is expensive and hardly worth your while.

Now we're going to check the inboard rolling hull for additional information about its safety. There is some risk inherent in this test, so put your life jacket on and secure any gear that could come adrift. Smoothly open the throttle to full speed and run in a straight line for a quarter of a mile. Now, with one hand on the ignition switch, put the helm hard over, turning a full circle so as to close again with your own wake, which you will enter from your "high" side, the side opposite to your direction of heel. In a steep right-hand turn, you'll parallel your wake on the port side of the boat. Don't try to keep the boat on its feet by shifting your weight to the higher side. If the boat seems about to spill and you have adequate control, you can recover stability by turning it in the opposite way. Should you lose control, cut the ignition and stick with the boat. (If you try to jump you may fall in the way of the propellers.)

When the boat recovers properly, as any adequately designed boat will, turn it at once, sharply and still at full speed, in the opposite direction and repeat the test. Always keep your hand on the ignition switch and remain in the same position so that your weight and the weight of your companion will have the same effect of normal trim. If this test seems unduly heroic, consider that some day under emergency conditions you may be running full speed and will have to turn to avoid a sudden obstacle such as a swimmer or another boat. It's easily within the ability of any designer and builder to provide you with a boat that is stable despite its power. It seems unnecessary to add that if the boat rolls over, it has failed its test.

### *Straight Run Tests*

Again, run at full throttle in a straight line for about one quarter of a mile. This time, turn so that you cross your own wake at right angles to it. Observe whether or not the boat pounds into the waves with a slamming action. Such action should be slight, although there will often be a noticeable slap. If the boat tries to stand up on its stern, then it's unsafe at this speed, marking a strike against it. You see, your ability to steer results from the flow of water past the rudder. If you are obliged to run too slowly in a head sea, you will have inadequate control, which is all the more awkward because the water is rough. If at any time in these tests you find you must slow down too much to keep proper steering control, you must consider that a larger rudder, with its concurrent expense, is necessary to ensure you a safe boat.

Notice, too, in these head-on wave conditions, whether or not the boat "pants," or tends to yield its hull or decking in the waves. This is a particular fault of improperly designed and built fiberglass boats. There is much misinformation about the high strength characteristics of fiberglass

and many builders and designers depend on the plastic and glass alone, neglecting important structural members which would ordinarily help the boats to keep their proper shape. Although inadequately proportioned hulls deflect and yield rather easily, they rarely come apart early in life. Instead, over a period of time, they fatigue and break down at the deck joints and bulkhead edges. Their engine beds are often so flexible that it is impossible to keep the engine and the shaft properly aligned.

In sailboats, panting generally allows the mast to sway. This condition may be either the cause or the effect of the fact that the mast step and deck partners come and go as the rigging is tightened or slackened by the yielding of the hull. As these parts move, the spar itself bends out of line and, in turn, increases the compression loading upon it at irregular points. The weather shrouds become useless and often the mast will fail. Moreover, it is impossible to keep a taut jib luff on such a boat; the harder you set up on the backstays the more aggravated the condition becomes.

**Testing the Hull and Sailboat Rig**

The tests we have run so far have applied equally to power boats and auxiliaries. Now we will test the sailboat rigs and hulls with some additional exercises before returning to the handling characteristics of the engine on our run back to the harbor.

While turning under power to parallel the wake, the sailboat observer should lower his centerboard its full length in the trunk. If the board slams heavily against the trunk walls as the sailboat rolls, it indicates that the clearance is too great within the trunk. This can be inexpensively corrected by padding the centerboard itself, building up extra thicknesses or "cheeks" on either face of the board with several layers of wood or fiberglass. If the board is metal, it can be taken from the boat and have cheeks of extra thickness brazed to it over the areas which remain in the trunk when the board is lowered. Tremendous impact can accompany this slamming action and if it has taken place over many years the trunk is often weakened structurally. Signs of such weakness will be weeping of water around the fastenings and seams when the boat rolls. Loose or sloppy keel bolts will also show this weeping about their inside heads.

The best cure is the simplest: loosen one bolt at a time, then work a thread of waxed flax packing underneath the washer and tighten the bolt again until it barely starts to crush the floor timber. In a fiberglass boat, tighten the bolts with a torque wrench, exerting a pull equal to the force with which you removed the bolt. If all the bolts were sloppy when you started work, set each one up with a torque of about forty foot pounds, gradually increasing torque until the leaking stops. In no case should the torque exceed fifty foot pounds. The torque wrench is a wrench with an



indicator attached to show the force you are exerting measured in foot pounds.

If you're testing an auxiliary sailboat, note the time you stop the engine. You'll want this information so you can tell the total number of hours the engine has been run when you check your fuel consumption later. Now, putting your companion at the helm, set the sails, starting with the mainsail. Notice if the halliards are frayed or worn, being careful of broken strands in wire rope. A worn wire halliard should be replaced at once. Not only has it outlived its usefulness but it has become a hazard to your sails and to your hands. A tiny wire fragment can cut you seriously; it can tear a sail well beyond repair. Wire rope is inexpensive and it is false economy to buy a cheaper grade than top-quality stainless steel.

When the mainsail is hoisted and made fast, sight along the sail track on the mast and boom. Have your assistant haul the sheet in flat, and watch to see if the track tries to pull away from either spar at any point. The usual spots for trouble in the track are at the head of the sail, at the gooseneck of the boom, and at the clew outhaul fitting. Usually, fitting an extra screw at these points will correct the condition. Sometimes, in older boats, you will find that the wood has broken down from rot or fatigue. Such wood must be cut out and replaced. In a small boat, under twenty feet for example, it may be less trouble and expense to make another spar. Next, set the working jib. This will be the size jib normally used on the boat in average weather conditions. Trim the sail in so that its luff is tight and the entire load which the jib stay has been carrying in its support of the mast is transferred to the jib. Have your assistant sheet the jib in as hard as he can, then go forward and sight along the stay, holding your head down near the deck. The stay and the jib luff should be very straight. Some slight concave curve may appear in the luff, but setting the backstay will remove any sign of it in a boat with a well-built spar.

One of the things you are checking now is the mast's ability to stand compression. Loading the halliards puts great force upon the mast which tries to contract to relieve itself. Since the halliards make fast to the spar itself in almost every boat, we put very little strain upon the hull and step. However, when we pull the sheets in tight and, in a wind, put pressure on the sails, the mast pulls against the sheets, the stays, and the shrouds. In turn, it delivers these forces against the mast step, the stem, and the weather side of the boat. You can see that if the mast grows shorter from compression or if the hull of the boat deflects when the mast bears down on it, one result will be that the distance between the top of the mast and the deck of the boat will decrease. Because of this, the quickest way to detect such mast compression or deflection of the hull and mast step is to examine the leeward shrouds. These will hang slack as the mast shortens. Of course, elasticity of the wire in the weather shrouds may show itself

as slackness on the lee side, but we can check for this somewhat by sighting along the track of the mainsail luff to see if the mast is bending. Generally a mast may bend an inch or two at the top without creating much of a problem. However, if it bends several inches, or takes on an S-shaped curve, we have the clue to a number of problems.

To understand these problems we must realize that the amount a wire stretches, for a given diameter, is in proportion to its length. Since our upper shrouds and stays are longest, we can expect them to yield the most. In a racing boat, where the rigging may be very small in diameter, the upper shrouds are usually set quite taut so as to reduce the amount that they will stretch. In a cruising boat, where there is really very little force delivered to the boat, the wires are often overstrength and proportionately slack. This is of course quite wrong, but most people rig cruisers in the expectation that they will be exposed to heavy weather.

Although they often are sailed through storms, the shapes and proportions of cruising boats make it impossible for them to feel forces anywhere near as strong as those to which the racing sailboat is exposed. The racer, you see, always carries her maximum possible amount of sail and balances it by her ballast, below. The moment the cruising boat feels hard-pressed she can readily shorten her rig and relieve the strain. But because, by her definition, she has accommodations and equipment on board representing greater weight than the racer, she carries less ballast on her keel. Also because her weight is high up relative to the weight of the racer, the cruising boat can more easily roll away from the impact of wind and wave and so diminish their force.

Now, if a mast should bend, we can deduce that the wires are too loose, the wires are too small, the mast is too weak, the mast step is too weak, or the rigging attachments are pulling loose. In older boats, these last two conditions are our first suspects. The only way to detect a weak mast step (assuming, of course, that you have already tested it for rot and fastenings in the inspection plan described in Chapter 1) is to watch it "work." Establish your eye level as near the mast step as you can and have your assistant alternately haul and slack the jib halliard. In calm sea conditions, this is about the maximum load that you will be able to place upon the step. If the water is rough, drive the boat close hauled against the seas, and watch the step for movement. Any detectable motion is too much. The answer is reconstruction of the mast step, a simple task. If the step moves the floor timbers of the boat with it, you have a major reconstruction job on hand and the boat would best be rejected unless she shows high quality in every other respect. You see, movement of the entire floor timber and mast step assembly involves movement of the garboards, keel, and often the stem. Usually bulkheads also are involved. The ramifications



of this failure may be very extensive and only a boat highly desirable in other respects merits the risk of such expense.

Look, too, for signs of leaking near the step and stem. These are almost conclusive evidence of a tired boat. If you're suspicious of the timbers and the step, but can't make up your mind, a dab of collodion, or nail polish, on the joints between the timbers and the step and planking will often help you to decide. If the collodion cracks or flakes away, the wood is in motion. To work the collodion test, the materials must be dry. Sometimes this can be managed by wiping the surfaces with a touch of acetone, or nail polish remover, which, when it evaporates, will carry off the surface water.

### *Fastenings*

While chain plates do loosen on old boats, the occurrence is not common. Assuming the hull to be structurally sound, the repairs are cheaply and easily made, usually by refastening. Chain plates are fully covered in Chapter 3. Mast fittings, on the other hand, are common offenders. High up on the spar, beyond the reach of the casual sailor, they rarely get their proper share of paint and preservative. Generally, the areas where tangs and mast attachments are secured grow weather-beaten, and even screws and bolts relax their grip in time. Often, inspection from the deck with binoculars will reveal pulled-out fastenings and rusted wire rope terminals. These should be repaired at once, because all decay is progressive. Spar repairs are often done inexpensively. Detailed instructions are given in the "Rigging" chapter. Again, if you are in doubt, have a boatyard take out the spars. The discovery beforehand of a large area of rot or decay in a mast of a sizable boat might save your life on the first rough day that you sail.

Stem head fittings and travelers rarely give trouble. The wood or fiberglass around them is subject to working, and, in wooden boats, rain may get beneath the fittings and cause rot. But, unless such rot is extensive, it is not too much of an indictment against the boat.

### *Examining the Sails*

Next in line to be examined are the sails. They should be clean, not mildewed, and in good repair. Torn or dirty sails which show spots of mold and of neglect are rarely worth the trouble to set them right. A sail in good condition, even though badly out of shape, can often be recut and made like new. The opposite bad condition is the slack, leeched sail. This sail has a trailing edge which flops over lifelessly when the sheet is hauled in close. Such sails are inefficient and, when you realize that the sails may represent between ten and thirty per cent of the total cost of your boat, they become intolerable. Repairs by a good sailmaker may run ten per cent

of the cost of a new sail. You can make such corrections yourself and, in Chapter 6, there are directions that will show you how. The too-flat sail, one with hardly any curve throughout its fore and aft direction is in a separate class with its counterpart, the drafty sail, which has its leading edge hang loose when it's close hauled. This kind of repair, although equally simple, nonetheless involves more effort because the sail rope must be moved. In head sails, or sails with wire luff ropes, you will be wiser to let a sailmaker do the repair work. An inadvertent encounter with a stainless-steel wire can fling a sewing machine needle a considerable and dangerous distance through the air.

## Getting under Way

If the wind is strong enough for sailing, put the boat on a close-hauled course; if she has a centerboard, lower it little by little until the helm is neutral or at its minimum pull. Under these conditions, leeway should be negligible. Check this by having your companion take the helm, holding the boat on the straightest course that he can steer. Now, face the stern and see whether or not the wake comes back in a straight line extending from the keel of the boat. If the wake seems to angle up to windward, the boat is slipping. Lower the centerboard all the way and see if the slipping stops.

All boats at one time or another make some leeway, but, if the wake angles up-wind more than two or three degrees, your boat is a bad offender. The cure, which is to increase the lateral resistance, is generally expensive. Adding area to the centerboard may include the necessity of altering the centerboard trunk, a major operation. Sometimes adding a small skeg to the keel, aft, will do the job, but this piece must be strong and well faired-in in order to carry the weight of the boat upon it during hauling and storage.

Occasionally, leeway results from the propeller of an auxiliary sailboat being stopped out of line with the deadwood and rudder. The aperture in which the propeller works is an up-and-down slit. The propeller, which on an auxiliary sailboat should always be two-bladed, must be lined up in such a way that the blades are parallel to the trailing and leading edges forming the boundary of the aperture. The propeller is swung into a vertical position which can be determined from inside the boat by a marking on the propeller shaft, and retained there by putting the engine into gear.

On a reach or dead before the wind, the boat should make no leeway at all, even with the centerboard raised into its trunk. Too, the boat should carry no lee helm. That is, any tendency she shows to turn should be to turn towards the side from which the wind is coming. Occasionally a boat will have a lee helm in extremely light wind conditions. This will always



disappear when the wind increases but it is nonetheless undesirable and is a mark against the boat.

### *Self-steering*

Another important characteristic which makes for seakindliness is the ability of a boat to steer itself when the sails and centerboard are properly trimmed. The only way to discover this ability in your boat is to experiment, first by trimming all the sails exactly for the course, then by raising or lowering the centerboard until the helm goes "dead." Even the best self-steering boats will wander some. They fall off the wind half a point or so, then head up and luff a moment before they fall off the wind again.

In general, the boats with the greatest inherent stability and most gentle curves throughout their hulls make the best self-steerers. This is not a vital characteristic of any boat, but it contributes greatly to the pleasure and safety of your sailing. The knowledge that you can leave the helm long enough to use the head, or brew a pot of tea, will encourage you to make many singlehanded passages you would otherwise avoid. Often a cruise is dropped before it starts because you cannot be sure of an extra hand to help you sail home. With a boat that tends itself, you will open harbors to your range of cruising that would otherwise be impossible.

Often, auxiliary sailboats and power boats are designed with the engine installation on a slant off to one side to provide this self-steering quality while under power. The "Engine" chapter of this book shows you diagrammatically how you may make such an installation if your boat does not already have an engine. Correcting the boat's steering under power by using various rudder devices is possible, but because of the extra drag of the equipment it is not efficient under sail.

### *Coming About*

Another phase of steering and sail balance is the boat's ability to come about. Many older designs of sailboat, and certain localized types, like the Bahama hulls, have long, straight keels which make them sluggish boats to turn. Try your boat when there is little wind and see if she will tack about from one reach to another. If she is slow to respond to her helm, it may be possible to cut away her forefoot and her skeg. This is expensive work, however, and is only worth while if the boat is outstanding in its other answers to your needs. Methods of altering the keel are discussed in the "Construction" chapter.

Finally, work the helm back and forth rapidly several times to be certain that it is not sloppy at low speeds. When the boat was under engine power, the slipstream of the propeller against the rudder would cushion any play in the rudder; before the boat left the mooring area, the rudder

may have been tight from inactivity. Now it has had time to limber up. If it works sloppily, the quadrant may be loose in a boat that steers by wheel; or a gear or a drum may be slack upon its shaft. A worn shaft bearing, or one needing grease, will often show some play.

In a boat that steers by tiller, check to see if the rudder-head fitting or tiller jaws are sprung. These corrections are all simple tightening jobs. The more serious problems occur in the rudder-shaft tube which makes the rudder post watertight and which may work loose from its fitting through the hull. Often, when the boat is dry, a wall of fiberglass tape can be built around these points, forming a flange to secure the pipe ends to the hull. This is at once the cheapest and simplest repair, when it is feasible. It is also the most lasting. However, when the hull is wet, the only answer may be to haul out the boat and to do carpentry as described in the "Construction" chapter.

Fit every sail aboard the boat and examine it as you did the working sails. If the boat has roller-reefing gear, that is, a mechanism for rotating the boom so that it rolls up the sail like a window shade in order to reduce its area, examine the gear for ease of working. Failure of such gear lies in any one of three conditions. The gear may be corroded, teeth may be missing from it, or its attachment to the boom may have worked loose. Corrosion is most easily removed by the use of penetrating oils and a wire brush. Broken teeth require brazing or a new casting, both cheaply done. A fitting which has loosened from the boom generally means carpentry work on the boom itself as it is almost always the wood that gives way. Such carpentry usually calls for simple replacement of the damaged wood, so it is a straightforward job that you can handle yourself.

### Returning to the Harbor

Now you are ready to return to the harbor. Note the time on your watch and start the engine after having sniffed the bilge for gas fumes. While your companion puts the sails away and sets the boat in order, relax at the helm and consider all your tests.

Safety is the most important thing in any boat. Is this boat structurally sound, as far as you can tell? Has she enough stability so that you feel confident when you are on board? Is she a pleasant boat to be with, or will she be a constant reminder to you of jobs that lie ahead? Does the boat seem huge to you, or too petite? Have you had adequate visibility at all times?

Have your assistant take the helm and go below. Listen to the engine and decide if its sound is too offensive. Some rainy day you may be confined below, trying to catch a little rest while someone else is at the helm. Does the cabin still smell fresh and sweet? Does the smoke from your cigar disappear through the ventilators, or does it linger in the cabin?



Are you conscious of the sound of fuel and water sloshing in the tanks? Inadequately baffled tanks can take on nightmare proportions in rough weather.

Lift the floorboards and look into the bilges with your flashlight. Has the boat leaked anywhere other than the stuffing boxes on this trip? Caulking is hard work, and takes time. Close the ports and hatches, then go on deck and fling several buckets of water hard against the cabin sides and decks. Now go below again and, with your flashlight, look for leaks. A leaky bottom is less bother than a leaky deck, even though you have to pump in either case, because the water in the bilge rarely wets your clothes and bedding.

When you reach the mooring, handle the boat yourself. Notice whether or not you can see easily as you dock. Notice again, at dead slow speed, if the boat responds at once to your control. Can you get from the helm to the bow and stern lines easily and safely? If the boat has slippery decks, but no life lines, or narrow catwalks and improper rails, she's a poor buy. Someday you may have to raise anchor from up forward all alone, then return quickly to the controls. In rough weather this could be suicide. Any boat that does not give you ample footing is a dangerous boat.

When the boat has been secured, stop the engine and note the time. Measure the fuel with a dip stick and find out if you've burned only a reasonable amount. One gallon per hour for fifteen horsepower is very economical. Three gallons for the same conditions constitute a lot. Depending on the age and condition of the motor, you must use your own judgment. The engine manual will have a chart showing what a new motor should consume. Check the oil level, noting whether the oil appears dirty from this run. If, after half an afternoon of motoring, the motor needs more oil it shows unhealthy tendencies.

Finally, having closed all intake valves, fuel valves, and water lines and having opened the main switch, get a distance from the boat and look her over. If she still retains her charm and you have satisfied yourself that she has passed her tests, you may safely feel that the boat is good. Remember that the only perfect boat is the one that you just sold. If you never lose sight of the concept that the purpose of a boat is to give you pleasure, you can soon decide where pleasure ends and work begins.

### Check List for Testing the Boat

1. Visual check (before starting)
   a. Does boat float level fore and aft?
   b. Does boat float level port and starboard?
   c. Are deck gear, dinghy, life rings, and general equipment in usable condition and properly secured?
   d. Is hull at water line clean from fouling?

e. Are spars and sails in good condition and properly secured against motion of the boat?
f. Are there at least two anchors and several hundred feet of suitable anchor line?
g. If the boat has an engine, are there at least two filled, usable fire extinguishers?
h. Are the bilges pumped completely dry?

2. Engine check
   a. Is engine filled with clean lubricating oil?
   b. Are fuel tanks filled to top?
   c. Make visual check for fuel- and oil-line leaks.
   d. Sniff area about engine for odors of leaking fuel.
   e. Is suitable tool kit aboard and ready for use?
   f. Does ammeter register zero when switch is open?
   g. When engine is started, does exhaust water flow from pipes?
   h. Do oil-pressure gauges show smooth increase in pressure as throttle is advanced and return to low pressure when throttle is closed?
   i. Do squeaks or vibrations indicate shaft misalignment or propeller damage?
   j. On twin-screw boats, do shafts rotate in opposite directions?
   k. Do engine gears engage with a positive locking action?
   l. Does engine temperature remain constant after reaching its peak?
   m. Is engine fuel consumption normal?
   n. Does oil remain clean and retain high level during test run?
   o. Do engines behave smoothly and powerfully through entire speed range?

3. Handling characteristics of boat under power
   a. Is boat positive and responsive through all speeds?
   b. Has boat stability?
   c. Does boat cut water cleanly and efficiently at all speeds?
   d. Does boat respond positively in reverse?
   e. Has boat good visibility?
   f. Has helmsman complete control of all handling factors of the boat without changing his position?
   g. Is sound of engines at low enough noise level so as not to be disturbing?
   h. Are there indications of backlash from propellers or vibrations from rudders?
   i. Has boat reasonably small turning radius?
   j. Are fuel and water tanks free from sound of sloshing of liquids, indicating great forces set up in tanks?

4. Characteristics of boat under sail
   a. Is boat responsive to helm regardless of direction of wind?



   b. Does boat have tendencies to carry strong lee helm?
   c. Does boat make noticeable leeway?
   d. Can boat be made self-steering by adjusting sail trim?
   e. Does boat sail at comfortable angle of heel?
   f. Are all ropes used for adjustment of sails or centerboard easily accessible from helmsman's position?
   g. Are spars and riggings sound?
   h. Does hull deflect the forces from spars or rigging?
   i. Is centerboard firm in trunk?
   j. Is propeller on auxiliary sailboat capable of being aligned to produce minimum drag under sail?
   k. Are sails in perfect condition or will they need work?
   l. Is rigging sufficiently simple so that one man can handle it all if necessary?

5. Motorboat construction
   a. Does hull show signs of "panting" in rough water or head sea?
   b. Does hull leak when driven hard?
   c. Are engine beds firm and vibrationless at all speeds?
   d. Are decks and hatches watertight?
   e. Is engine easily accessible for all parts?
   f. Are all parts of steering equipment easily accessible?
   g. Are decks and superstructure completely resistant to deflection from walking, jumping, and sea conditions?
   h. Do fuel and water tanks remain properly fixed in their positions?
   i. On outboard power boats, do transom and stern structural members remain rigid and vibration resistant throughout?
   j. Has outboard runabout proper weight distribution so that it is safe at all speeds?
   k. Has outboard runabout built-in flotation units so it will not sink if capsized or swamped?
   l. Does outboard cruiser have means of easy access to engines?

6. Construction characteristics of sailboats
   a. Does sailboat resist deflection and "panting" both from sea and from rig forces?
   b. Are sailboat hull and deck completely watertight?
   c. Is sailboat watertight in area of centerboard trunk, keel bolts, and transom?
   d. Is sailboat watertight in area of mast step?
   e. Is mast step absolutely rigid both in itself and against keel and floor?
   f. Are chain plates, stemhead fittings, rigging attachments and tangs firm and sound?
   g. Are rudder, rudder head, and quadrant or tiller attachments strong and firm?

h. Has deck been weakened in area about mast from motion of mast or from overly tight wedges?

7. General characteristics for all boats
   a. Is noise level of entire boat from all sources including engine and boat vibration acceptable?
   b. Does boat establish a general feeling of rapport with and responsiveness to the helmsman?
   c. Does boat seem well within the physical and technical capabilities of the helmsman?
   d. Is this a boat which you will feel proud to own?
   e. Do the number of changes which you think you will make form a substantial total of work that must be done to the boat before you will feel she is ready for real enjoyment?
   f. Will the changes you feel you should make alter the boat in such a way that they might interfere with its resale value?

CHAPTER 3

# Outfitting the Boat

Outfitting, in the sense with which we shall use it in this chapter, means putting the boat in ready-to-use condition, afloat and in seaworthy shape. Ordinarily, after a winter's lay up, a boat needs very little refinishing before being put back in the water. Antifouling painting, repainting of topsides, decks and superstructure, and refinishing of varnish and brightwork usually will be all the work necessary for the well-being of her hull. A check up of the engine and other mechanical parts such as the stove and water closet are also an important part of the seasonal routine. Boats kept on trailers or stored ashore between periods of use will need less attention than those which live in water throughout the entire season. When the former type of boat has an engine, it is usually only necessary to flush it with fresh water after each use as a preventative measure against corrosion and to follow the ordinary engine lubrication instructions to protect it against wear. However, when a boat of any size is in need of major overhaul, the practices described in this chapter are effective measures for the job.

## REFINISHING YOUR BOAT

Let's begin in the boatyard, where the vessel is stored, dried out from months on land, with her seams open and her paint and varnish old. We will assume that you will have to remove much of the old finish, replace some of the caulking, refinish the hull and spars, put the engine in good working order, check the toilet and the galley stove, make sure that the

fire extinguishers are up to par and attend to a dozen other details that make up the work called "ship's husbandry."

The suggested plan of work is this:

1. Remove old finish from interior.
2. Do all interior "dirty" work on engine, machinery, and gear.
3. Clean and refinish interior.
4. Remove old finish from cabin and decks.
5. Refinish cabin exterior and cabin top.
6. Refinish decks.
7. Remove old finish from topsides and hull.
8. Refinish topsides and hull.
9. Paint bottom of hull with antifouling paint.

The reasons behind this sequence should be obvious to you. During your work you will be climbing in and out of the boat, moving ladders about and dripping paint and debris from every level of the hull to all the levels beneath the paint where you are working. An example of how this works may show you how to take better advantage of this plan.

Let us suppose that you have removed the old paint from the topsides of the hull and sanded the wood down preparatory to refinishing. Now, even though you have not yet put on paint because you plan to do the decks and superstructure first, an accidental spill of paint remover from the deck or cabin, or a day of rain, will carry down so much dirt to the hull itself that you will be obliged to prepare the surface all over again before you can put on the finish. However, if your decks and superstructure are already cleaned and finished in their bright new paint and varnish there will be very little dirt that can be transferred to the surfaces below them. You see, the force of gravity is important even in the painting of a boat and the more ways in which you learn to take advantage of it, the simpler your task becomes. You can see from all this that the basic rule is very simple: You simply start at the highest point of the boat, even if it is the top of the mast, and work downward so that your cleanest area is always above the next area on which you will be working.

## Removing Old Finish

Paint which has accumulated in many layers has little strength in proportion to its thickness. Because of this it will break down from its own mass, leaving a surface which is unsightly and, worse, susceptible to the worms, rot and rust which will appear when the hull has been exposed through the damaged finish. (Of course, this is not true for fiberglass boats because here the hull is painted only for appearance, not for protection.) Such damaged paint will soon begin to work itself loose from the surface and flake off in scales. If you are fortunate enough to discover that the old paint on your boat is in fairly good repair, all that is necessary is for you



to sand off the outermost layer of oxidized, dirty material, exposing a fresh, smooth surface for repainting. However, you could be confronted with an irregular, cracked, blistered surface that must be scraped down to bare hull material before a new finish can be applied. So, at this point, we will stop and consider the different tools to be used for these two extremes.

### *Sandpaper*

Sandpaper is a generic term loosely applied to a number of abrasive papers and, as these papers are among the most important tools we have, it is necessary to understand their various uses. Abrasive papers are used as gross removers of material surface finishers. Because paint, putty, varnish and plastics tend to clog the spaces between the grains of an abrasive, it is best to specify "open coat" papers for use on such finishes. Open coat papers have widely spaced abrasive particles that have little chance of retaining any of the material to which they are applied. For finishing the surface of bare wood, however, a "closed coat" paper should be used. Here, the closely spaced grains of abrasive evenly dress down the grain of the wood so that the final surface is very smooth. These two types of abrasive paper are classified as "dry" papers in contrast to the "wet-or-dry" papers, which we will discuss next. Dry papers are used directly on a surface, without the addition of a lubricant; wet-or-dry papers are lubricated by water or kerosene. The best material available today for a dry paper abrasive is aluminum oxide. Be certain that you insist upon this type; it is worth going to a good deal of trouble to obtain because it is many times superior to any other, even though the salesman may insist that garnet is just as good.

Wet-or-dry papers are used on the final coat of finish to give a nearly perfect satin smoothness to paint and varnish. The surface upon which you are working should be kept wet with water or with kerosene, and the paper itself washed frequently as you sand. You haven't much choice of abrasives for surfaces here; and they all seem to be about equal in quality. Although the use of kerosene as a sanding fluid is common, it is both dirty and dangerous. A much better choice is water to which has been added a good measure of any common household detergent. The detergent cuts the airborne oils that have settled on the finish and makes it easy to wash down the surface thoroughly, leaving it clean and smooth.

### *Sanding Machines*

There are three basic types of sanding machines: the disc sander, the belt sander, and the vibrating sander. The disc sander, which can be easily made by attaching a sanding head to an electric drill, is a superb material remover, but it is useless for anything else except polishing. For polishing, a sheepskin pad is fitted over the flexible disc against which abrasive paper

is ordinarily backed. Sheepskin pads made especially for this purpose are available in hardware stores.

A belt sander is also an excellent material remover. Moreover, in the hands of a very skilled operator it can be used for finishing. Because the belt carrying the abrasive moves only in one direction this machine will not damage the grain of the wood nor cause it to swell. It is the only fast-working mechanical sanding device which, expertly used, can be applied to bare wood before finishing with clear varnish or lacquer.

The orbital and axial sanders are strictly finishing machines. The pad of the orbital sander, carrying the abrasive paper, moves in all directions and so should never be used on bare wood. The axial sander is safe to use in this application but has so small a stroke that it cuts very slowly. However, for smoothing the butt ends of woods it is quite satisfactory. In general, these two classes of sanders are most effective in removing the outer layer of old, oxidized varnish or in building layers of new varnish after the first coat has been applied to the wood to fill the grain.

### *Abrasives for Metal and Fiberglass*

Various metals respond in characteristic ways to treatment by abrasives. For smoothing rough castings of bronze or aluminum, aluminum oxide papers are superior to emery cloths, which are abrasive-coated fabrics. For use on iron, steel, Monel, and metal plating such as cadmium, emery cloth is the proper abrasive. Crocus cloth, a superfine version of emery cloth, is used for the final abrasive polish before rouging or buffing surfaces of metal.

A superb instrument for cutting fiberglass-reinforced plastics and metals is the "vixen" file, sometimes called an automobile-body file. The cutting edges of this file consist of a series of razorlike arcs so that to keep from injuring your hands you must either equip it with a pair of wooden handles or wear work gloves while using it. For finishing hard, or cured, fiberglass, abrasive paper and files are essential, but when the resin is newly set it can be cut cleanly and smoothly with a sharp hook scraper. This instrument, in the hands of an experienced worker, is fine for the removal of any material. Be sure to purchase the kind which accepts replaceable blades, and buy a good quality blade file as well. These scraper blades must be kept absolutely sharp and straight. When they get dull they soon clog and start to chatter. The chattering, or vibration, makes them difficult to control and, should one of the blades slip, it can do a lot of damage quickly. Also, while the cutting edge must be kept sharp, it's a good idea to dull the tips of the blades with your file so that they cannot accidentally gouge the material.

A wide-bladed putty knife with a stiff, straight edge is a valuable tool. You'll use it a lot when you work with paint removers but it is also practical for flaking off areas of cracked finish. You should have two of these knives. The larger one should be about four inches wide and the smaller one, about one inch wide, should have a moderately flexible blade because it will also be useful for puttying proper.



### *Paint Removers*

Paint removers available on the market today are so effective that there is no valid reason for the small boatowner to suffer the labor of sanding or to risk the explosion hazards of paint burning. The secrets of success in the use of chemical removers are few, but quite important.

First, you must learn to let the chemical do the work. This means that you should plan your labor so that you can make steady progress. The procedure you should follow is to apply the remover generously to a small surface, then let the chemical remain in place until the paint has softened in big blisters. To save time, you can work on two areas at once, applying the remover to one area and allowing it to react while you peel the paint from the area you have previously treated.

Try to schedule your movements so that you always work on the shaded side of the boat. Sunlight hardens the chemical paint remover because it makes the volatile components evaporate.

Be sure your working surface is dry before you apply the remover; rain or dew will shield the remover from the paint and will dilute it as well.

Finally, use fireproof nonrunning removers.

It is best to apply the liquid with a brush and protect your hands with work gloves, preferably of a rubber-coated fabric that feels cool to the skin. Be careful not to breathe the fumes of the remover or get it on your face or in your eyes. If this should happen, fresh water is the antidote. Use a lot of water and continue the treatment for several minutes.

Incidentally, there is no need to work yourself to death taking off paint until the wood looks "new." Once you have a smooth firm surface in the grain it makes an excellent filler to undercoat your new finish.

Most nonrunning removers contain wax as their thickening agent. Wax is almost chemically inert and leaves a film. Paint or varnish can't get an adequate mechanical hold on the wax so it must be removed before you can refinish. Because wax will quickly clog any abrasive paper, it is most easily removed by scrubbing with fresh water in which both soap and detergent are mixed. (The detergent acts as a wetting agent which breaks up the surface tension of the water and the soap aids further in emulsifying the wax.) After a thorough scrubbing, wash the boat down well with fresh water and let it thoroughly dry out before you paint or varnish. This is also a good practice to follow after the use of the neutralizers required by certain brands of paint remover.

When the old finish has been removed from oxidizing metals like iron,

it is best to put on a new protective surface immediately to prevent further oxidation. A badly rusted iron keel, rudder, or other underwater part may first need chipping to remove large flakes of oxide. Always wear goggles when you do this job. Purchase a chipping hammer with two edges at right angles to one another, and keep these edges sharp. When the iron has been chipped clean, wire-brush off the fine, dustlike rust immediately on the surface and wipe it from the metal. Fill all the crevices with an iron putty such as Gabriel Metal, Devcon, or fender putty and then apply several coats of rust-protective finish. Some fine brands are Rustoleum, International, and Val-Oil. Despite the claims of the advertisers, these products don't vary much. Moreover, the contents of these finishes are less important than the fact that air is sealed away from the metal. The best protection, if you can afford the cost, is galvanizing with a spray of hot zinc. However, no coating remains effective after it has been scratched through to the metal beneath, so be sure that you do a thorough job.

**Gluing**

After a boat is wooded down (stripped of its old finish) you will have a good opportunity to examine the seams and fastening bungs. Loose bungs (dowels which stop up holes through the hull or countersunk areas around fastening heads) should be removed and replaced. Examine the heads of the fastenings underneath these bungs. If they are rusted, chip this rust away until the fastening head is clean, and daub in a coat of rust preventer. Let the rust preventer dry, then set in a new bung, using a waterproof glue to retain it. Remember that there are only two *waterproof* glues that can do this job. They are Elmer's Waterproof Glue, and Weldwood Waterproof Glue. It is important that you check the label of the can yourself to be certain that you have the proper glue, because each of these firms produces several different kinds. Both of the glues specified here are packaged in two parts: a resin and an activator. A one-can glue is not available at this time for the job.

**Caulking**

It is hard for the beginner to tell whether or not a boat needs caulking. Unless she's very old, perhaps more than twenty years of age, she probably does not. Unless you can see daylight through most of the underwater seams, and the caulking cotton between the planks has been compressed until it is flat and ragged, it's much safer to assume that a fresh application of elastic seam compound is all that your boat requires.

There are a variety of elastic seam compounds on the market; one of the best and easiest to apply is Kuhl's. Kuhl's compounds are different for above- and below-water seams and it is highly important that you choose



the proper kind. Regardless of the type that you do use, the method of application is the same. Force the compound well up into the seam with a fairly stiff spatula, using the smallest amount of material necessary to fill the gap. If you force in an excess of compound, it will be driven out again when the planking swells and, besides making the boat appear unsightly, it will injure the paint by cracking it and thus enable marine growth to take hold. Even if you use your boat in fresh water, marine growth can be a hazard. It is very detrimental to performance under sail or power and, even in fresh-water areas, wood-boring marine life can be found.

If you discover that it is really necessary to use caulking cotton in some of the seams in your boat, there are some simple precautions that you should follow. Be careful to work the cotton into place in an even strand, not bunched or flattened. A slightly sharpened metal disc, set in a heavy handle and called a caulking wheel, is used to roll in the cotton. If you have no caulking wheel it is enough to press the cotton gently into the seams with a dull spatula. No caulking material should ever be driven with force into the seams of a small boat. When wood swells, it exerts tremendous force and, if the caulking is packed hard, the planks will work against it from opposite sides. Enough pressure can easily develop from this so that planks, frames, or fastenings are split, seriously damaging the boat and aggravating the leak as well.

**Treating Scars and Abrasions**

Minor surface scars and abrasions are all part of the normal lot which befall boats. With modern materials these scars are easily filled and dressed. For wooden boats, the best material for filling these wounds is Famowood, a synthetic filler available in mixtures which accurately match the appearance of any kind of wood. (Serious damage repairs must be made in more drastic ways that will be discussed in the chapter on "Construction.")

Minor damage to fiberglass boats can also be glazed with Famowood if the boat is to be painted later. Otherwise, the use of a resin or resin putty is necessary. This putty is made of thixotropic (nonsag) resin to which matching pigment and fine chopped-strand glass are added. The resin must be activated by the user before these products are mixed into it, otherwise it is difficult to distribute the activator uniformly. The resulting putty is brushed or spatulated in place. (For this general type of work the polyester resins are quite satisfactory but, if the damaged area is extensive, an epoxy resin will hold best.)

When the resin putty has cured, the repaired area is dressed down with wet-or-dry abrasive paper. Most of the molded fiberglass-reinforced plastic boats manufactured today are finished in a thick layer of pigmented resin called "gel-coat." While repairs to a surface with this material can be made, it is hard to do a good job because the gel-coat requires rather special

drying conditions, usually including the absence of air. It is generally best to repair damage to a gel-coat surface using ordinary resin putties in the manner described above.

The amount of time required for resin putty repairs to cure can be very much reduced by heating the area of the repair with several infrared lamps after the putty has been applied. If the area is so large that the putty shows a tendency to sag it is best to accomplish the repair layer by layer. By using several thinner layers of material, and allowing each layer to dry quite rough, without making any attempt to mold it smooth, the successive layers will bond in a perfectly satisfactory manner and make for a good repair.

Surface damage to metal boats is difficult to treat. Iron or steel hulls may have to be hammered, welded, or filled with Gabriel Metal or Devcon. Although some fiberglass repairs have been made to metal hulls, the bond attained by the plastic generally breaks down because the metal deteriorates through oxidation. The same problem that plagues iron and steel boats applies to aluminum boats. Once the metal starts to go, there isn't much hope that it can be saved. You may delay the end by using fiberglass or by aluminum soldering, but these are only stopgap measures. Surface damage from abrasion, however, can be readily puttied with epoxy resin mixes. The metal must be thoroughly cleaned, dry, and sanded until it is rough, before the resin putty is applied.

**Priming**

Any virgin surface requires a priming coat before it is painted. Even lacquer and varnish finishes, referred to as "brightwork," appreciate this treatment and, because one of the best primers for wood is also good for metal, we shall touch upon it first.

Brightwork would appear extremely uneven in color if the wood were not first stained with a "filler." (Fillers are dense, oily pigments rubbed into the grain of freshly sanded wood, after which the excess filler is wiped away. They mask the wood's color variations, making spruce spars, mahogany trim, and walnut cabinets appear as if the woods were all exactly matched for every part.) After the filler is dry, the priming coat of finish is applied. Now, all varnishes available today have natural colors of their own, so it is important to match the filler to the varnish. For example, using a dark mahogany-colored filler on dark mahogany and then applying a deep amber-colored varnish on top of this combinaton might give you an appearance quite different from that of any other wood aboard your boat. Always try a small sample area which you can readily sand down again before you tackle an entire job.

The only available primer for brightwork is Val-Oil, and it is a remarkable product because it is both good and inexpensive. Val-Oil makes a fine undercoat for varnish or for paint. It bonds these finishes to itself and bonds itself to wood or metal quite tenaciously. You can even add pigment to this product and use the mixture for an entire finishing job. It is rather heat resistant, and seems to make a superior engine paint. It serves best when the first coat of varnish or paint is applied to the Val-Oil without having sanded the slight raising of the grain which the Val-Oil brings out in wood. Once this first finish coat has dried, however, you should sand to even up the work.



For priming new or raw wood, any good oil-base paint is satisfactory. It is a good idea to dilute the paint about ten per cent by volume with turpentine because it will penetrate better this way.

Some metals, like Monel, aluminum and brass are unkind to the adhesion qualities of ordinary paint. This is because these metals are naturally oily and provide no molecular foothold for the chemicals in the paint. In such cases you must use a metal primer coat first. This type of primer generally is designed to slightly etch the surface of the metal on contacting it in order to provide secure footholds for the mechanical adhesion of the paint.

New fiberglass-reinforced plastic surfaces require priming coats but older surfaces will hold paint without this need. The reason behind this is that the plastics cure over a long period of time. One of the by-products of this cure is called "monomere" and is given off by the resin to the air. When the monomere comes off, it destroys the bonding of the paint. Some primers for polyester and epoxy resins are made by Valspar, by Pettit, and by Woolsey. The resin distributors themselves also recommend some primers, notably the Boat Armour Corporation, which packages a good primer.

In any case, cleanliness of the surface before applying the primer is the most important factor in your control. Any foreign matter which imposes itself between the new finish and the old acts in such a way as to interrupt the bonding of the layers. The most commonly present and most often neglected detriment to a good finish is contamination by airborne oils and dust. It is always good practice to wipe down the area on which you are going to work immediately before applying your new finish. A clean rag moistened with acetone makes an excellent instrument for this purpose.

**Brightwork**

The method of building a good varnish finish is somewhat different from that used for other coatings. In contrast to paint, which is built into a surface by many thin layers brushed on as thinly as possible, varnish is applied by a flowing technique, and must be distributed continuously and generously. Use the fullest-bodied, most long-bristled nylon brush that fits the job. Always work in only one direction. The surface you are going to varnish must be dust free, dry and at a temperature between 75° F. and 85° F. before you begin. One exception to this temperature range requirement is called "chilled varnish," a specialized product which you refrigerate

before using. It is nothing more than a very high quality varnish which can be used in adverse weather. Most other high quality varnishes can be used in the same manner but, as their characteristics vary, you might get into trouble by experimenting with them.

Just before the varnish has dried hard, it should be lightly cleaned with a tack cloth of lint-free fabric to remove dust and insects. When it is hard, sand lightly and evenly with the finest grade of abrasive paper. Carefully brush or blow away all the dust from your sanding and flow on the next coat. Never build fewer than three thicknesses of varnish coats. Six coats are even better. For a perfect final polish, if you have the time and patience, rub down the last coat of varnish with oil and pumice, then clean it off and wax it.

There are some excellent "soft" varnishes on the market, today, which make a beautiful finish, particularly on interior work. If the wood is well matched, close grained, and thoroughly clean, a superb finish can be built up from wax alone. Some woods, like walnut, butternut, and holly look especially attractive this way but the wax finish offers no protection from bumps, so don't use it where damage is likely to occur. The best areas to which wax is suited are bulkheads in the main cabin where heavy gear is not often handled, dining tables, and interior trim. It is never wise to use wax above decks because it is too exposed to abrasion. The hard, paste waxes like those used for protecting automobile surfaces are the best. Wax will last better on wood which has been saturated first with Val-Oil than on wood to which it is applied directly. The principal advantage of wax is that it is easy to maintain and to "freshen-up." Moreover, it is more gentle to the eyes than varnish because it is not so reflective and this characteristic can be a blessing on a summer day when reflections from the water and the boat's exterior are strong and harsh.

A fine finish can be obtained on new wood by laying thin fiberglass fabric or glass veil in a coat of clear polyester resin, then sanding with wet-and-dry paper. Never use the resin without the glass, however, or it will craze and crack. The technique is to brush a thin coat of resin onto the wood, allow it to get tacky and work the glass evenly across its surface before it sets. Use a minimum of resin and build several coats, if necessary. Choose glass with a loose, open pattern and a style which has had its surface treated to help the resin to flow. There are a number of such surface treatments, two well-known ones being Chrome and Volan. Although most boatyards carry fiberglass fabric, it may be necessary to place a special order to obtain the extremely thin varieties of veil. You can locate the supplier nearest you by addressing a letter of inquiry to Owens-Corning Fiberglas Corporation, Reinforced Plastics Division, 717 Fifth Avenue, New York 22, New York. In fiberglass-reinforced plastic surfacing like that just described, the weave of the glass will be almost invisible when the



job is done. The grain of the wood, however, will show through clearly. Not only does this make an attractive finish, but it is singularly good treatment for wood spars in areas where there is considerable chafing from sails and rigging.

**Paintwork**

The technique of building a good surface with paint is less painstaking than with varnish. The method is somewhat the reverse. While varnish is applied in a heavy, continuous flow, the secret of painting is to brush in many coats of very thin paint, glazing defects with putty, and sanding between every coat after the prime coat has been applied.

Paints are classed as gloss, semigloss, and flat, the last paint being chalklike so that dirt and discoloration are easily scrubbed off. The disadvantage of the flat variety is that the paint itself is dirty, rubbing off on hands, clothing, sails and lines. However in some areas where the water is filled with oil and dirt, as in New York and New Orleans, the flat paints are the only ones which are practical.

One answer is semigloss. It is flat enough to be easy to clean, and, not being glossy, does not accent every imperfection in the surface of the boat by harshly reflecting light. Semigloss paints are very good, too, in conjunction with nonskidding additions when used on decks and cabin tops. One of the best nonskidding materials is called "Skidless Compound" and is made by Pettit. The product has an altogether neutral color. It is packaged as a dry powder which you add to the deck paint of your choice, and it is very inexpensive. Use it in small amounts, taking care to keep it well stirred before each brush stroke. This compound is also highly compatible with the resins used with fiberglass and it is advisable to add it to them as a final coat for any walking area.

Gloss paints wear the best. They may be the most difficult to clean and may exaggerate every fault of the boat, but on a boat which has fine surfaces these paints provide a beautiful finish. Gloss paints also have great physical hardness so they give the boat a certain protection against damage from impact and abrasion.

Sun and water are great enemies of paint and varnish. Water, which can dissolve almost anything if given time enough, gradually breaks down many chemicals in a finish, while heat from the sun not only helps the water in this destruction but rays like the ultraviolet further weaken the material. Then, the alternate expansion and contraction of the surface material, which is first cooked by the heat of the sun, then chilled by rain, not only works to tear the finish from the hull but also tends to destroy the material itself.

At the present time there are two different approaches to the solution of this problem. Certain synthetic paints, called the vinyl-base paints, are

highly elastic. Because they are able to stretch and relax continuously within a considerable range, they last remarkably well and have excellent water-resisting qualities. The vinyl paints particularly recommend themselves to old or lightly built boats where there is considerable movement of the seams, and where ordinary oil-base paints might crack and leak, or flake away, the vinyl paints will usually last much longer. Vinyl paints have even been developed to include a range of antifouling finishes. One of the best of these is called "Navicoat."

The opposite approach to that taken by the vinyl paints leads us to the epoxy-based paints. These paints contain pigmented epoxy resin. They are fantastic adhesives and have tremendous physical strength. However, they are not particularly elastic. Where the vinyl-based paints resist damage by yielding to ill treatment, the epoxies resist it by brute force. On a seamless boat, such as one made of fiberglass, plywood, or metal, epoxy paint would be an excellent choice.

Both the epoxy- and the vinyl-based paints have a common and major disadvantage: They are terribly difficult to remove once they become old. On the other hand, their good points outweigh this disadvantage. They are long lasting, very protective, easy to apply and make a fine appearance. They are certainly the paints of the future and are available for our experimentation and use today.

### *Colors*

While there are some dazzling combinations on the paint-manufacturers' color charts, you should not purchase any of them until you have considered some factors other than taste. There is an entire field of science devoted to color, and over the past half-century some valuable things have been learned. The first of these is the relationship of colors to temperature and to strength.

Dark surfaces transmit and radiate heat more than do light ones and it is important to consider this from a standpoint of comfort and use. If you sail your boat in northern waters or waters below 40° south, you will want the comfort that sunlight on a chilly day affords. Under these conditions, a buff, brown, or dark gray deck can be advantageous. Dark topsides, too, in cold regions, will allow warmth to enter the boat, but in both cases a price is exacted. The outer surface, taking on heat, begins to dry. In a planked boat this means movement of the wood and the opening of seams or the straining of glue bonds. When fresh water enters these seams, as when dew forms at night, or when rain falls on the boat, an environment encouraging to rot may be created. Decks and topsides become leaky and demand more maintenance. If you choose the warm color, then, you must first consider the dangers it entails for the boat.

In contrast to the dark colors, light ones are kind to the boat because



they are definitely cool. In southern waters, and those of the same latitude below the equator, this is a decided advantage. In one specific case of an auxiliary sailboat from Florida, changing the color of the topsides from navy blue to white doubled the time that ice would keep in the refrigerator. Light colors, you see, will reflect more infrared light waves than they transmit. It is the infrared series of waves that we know as heat. Light colors also seem to have some slight, inherent antifouling ability, apparently because by not absorbing heat they don't make the boat a warmer environment than the water itself, thus attracting growths. Moreover, because of the reduced heat transmission, planks and seams of wooden boats don't dry out as readily when they are painted with light colors. The paint itself lasts longer for two reasons: it does not expand and contract as much from heat absorption; it does not absorb as much radiation, which would speed up its aging.

Strong colors of high saturation, or intensity, absorb so much sun radiation that they quickly fade. The dark reds, deep blues, strong greens and black are usually the worst offenders. Black, while handsome, is most difficult to maintain and is often damaging to the wood beneath it because of heat radiation. A boat which has been painted a dark color is more prone to rot than one which has been painted in lighter shades.

Fading is a serious problem that is most easily solved by choosing pastel shades of color. Pale blues and greens are much more durable than their stronger hues or saturations. Another point: It is advisable to keep cabin tops and decks as white as possible because this increases visibility from the air. If you ever get in trouble a searching plane can pick you up more readily if the upper surfaces of your boat reflect the maximum quantity of light. A special color called "blazer red" has been developed for high visibility. It would be far too disturbing to the eyes to use for ordinary deck or cabin top paint, but, if you carry life rings or a raft, this would be an excellent color to choose for them. Reflecting paper is made in this same color for night safety markings. A roll of this paper kept aboard as insurance for emergencies would be a worthwhile investment. When you wish to attract attention, you can roll the paper out on deck and hold it down with thumb tacks to assist visibility from the air.

### *Antifouling Paints*

The value of each variety of antifouling paint depends upon the waters in which it will be used. Unfortunately, it seems that the quality of such paints is directly related to the cost, but there is a breakoff point above which you are probably paying for advertising. The best answer lies in experimenting yourself. The paints which scare the worms in Alaska may be no more than appetizers for the worms in New Orleans.

The most important point to remember about antifouling paint is *don't*

"thin it out a little to help it flow." These paints are very critical, chemically, and if the directions say you can add 10 per cent of thinner, be sure you add no more than that and use only the thinner recommended by the manufacturer of the paint.

Because these paints contains metal solutions, you must be careful not to use them over certain metal hulls and parts. If the manufacturer does not mention prohibited metals on the label, you are fairly safe. However, some mercury paints react with some aluminum boats, some iron boats, and some brass fittings. The same holds for any other antifouling paint you choose. Therefore, it is important to check the directions on the can. If you are in doubt, write to the manufacturer.

Be certain to work antifouling paint in behind the rudder, along the bottom of the keel, into the centerboard well, and up the through-hull fitting. Often a swab made of rags on a slender stick will facilitate this. A turkey feather is useful for getting the paint into some areas. While many boatyards insist that they do this work for you, it is essential that you check it before the boat is launched.

There are some areas where it is important not to paint, and these are the zinc pads occasionally found on hulls, propellers, rudder shafts (where they are used as antielectrolysis devices) and on the radio ground plates. Paint insulates these and makes them inoperative. Some people prefer not to paint propellers and propeller shafts. If you have a motorboat in constant use, this is all right, because they won't foul and in fact will turn with less resistance. But, whether you sail in salt water or fresh, if your boat remains overboard during the season and lies idle between week ends, by all means use bottom paint.

### *Painting Tools*

As we noted in the section about varnishing, the best brushes available today are made of nylon. In all materials there is a variety of qualities, so choose big, full brushes having very springy bristles and metal ferrules that won't work loose. A particularly useful brush for tight work on water lines and scupper rails is called a sash brush, and has its bristles cut on a slight angle.

Treat your brushes like the fine tools they are, cleaning them in several separate washes of kerosene or mineral spirits immediately after use. When the finish has been thoroughly washed from the bristles, wash the brush in mild soap and water, dry it, and then store it flat. Brushes stacked on their bristles or their handles soon grow ragged and useless.

You should have one set of brushes for varnish, one set for paint, and a different set for fiberglass resins. The brushes used for resin must be cleaned in acetone, styrene, or toluene, and they must be cleaned at once after each use. Because the resin solvents are all very active chemicals, be especially sure to use nylon for brushes and nylon or mohair carpet fabric for rollers. Rolling paint or resin does not allow you to establish a first-class, finished surface, but it may speed up the laying of priming coats. The most common rollers are made from Dynel, a synthetic fiber which immediately dissolves in the cleaners used for resin. Avoid these rollers at all costs. You can quickly and cheaply make good rollers yourself by purchasing carpet remnants of mohair, sewing them into cylinders with the bottom of the carpeting "outside," and then turning them inside out.



Although paint spraying devices are mostly used for special professional applications, there are times when they can be quite handy to the boat owner so we will consider some of their characteristics and uses.

Spray guns operate either by creating a high pressure in the gun, a low pressure in the nozzle, or by a Pitot action, somewhat like that of a perfume atomizer. The mechanism for generating whichever pressure system is used may be in the gun itself or may consist of a separate pump connected to the gun by tubing. The self-contained units are toys, although their advertisers make some powerful claims. We shall concern ourselves with guns using about forty pounds of pressure generated by an outside source. As we shall not discuss the spraying of plastics in this section, it is unimportant whether the spray-gun nozzle mixes its fluids internally or externally. However, if you purchase a gun to use in building a boat of fiberglass-reinforced plastic, be certain that it has external mix nozzles and that it will generate and carry at least eighty pounds of air pressure. Spray guns of this design are excellent tools and facilitate the building of many layers of fiberglass-reinforced plastic. This is because, with a gun, it is simple to spread a small amount of plastic uniformly over a large area. This spread of plastic can then be allowed to set to a "tacky" finish which is just adhesive enough to retain a layer of fabric in working position. Then, without further handling of the fabric, the laminate can be saturated with resin cleanly and quickly by controlling the nozzle aperture and the pressure of the gun.

The spray gun is especially helpful in applying antifouling paint inside a centerboard well, or in distributing preservatives to the inaccessible tops of deck beams and stringers, far forward and aft in the hull where working space is limited, and inside cupboards and lockers. Always strain paint through cheescloth before you put it in the gun or it will surely clog. You must clean the gun immediately after using, disassembling all the working parts and wiping them dry. After reassembling the gun, spray a bit of unused cleaner through the nozzles and jets as a precaution against any oversight in the cleaning operation.

There are usually several nozzles available to fit each type of gun. The most common have pinhole apertures which throw a cone of spray. Some, however, have slit nozzles and these throw a wide, flat spray which you can paint with as you would with a brush. This type is especially good for

working in the centerboard well. As with painting and varnishing by brush and roller, you should always deliver the spray in a way which cooperates with gravity. Start from the highest point and work down. Always keep a spray gun in motion, however slight. If you spray in one area for more than a moment you will deposit an excess of material that will run.

Some paints today are available in self-charged spray cans. These are very effective and are excellent touch-up bargains to keep aboard. If you use any of these sprays in the boatyard, be extra careful that no wind can carry your spray to another boat. This can be particularly hazardous if blowtorches or other fire devices are downwind of you. It can also become expensive if the other boat is a different color from your own.

### Commissioning the Engine

As with all equipment which has fittings passing through the hull, the most important part of commissioning the engine is checking the water-tight integrity of the entire system. We can divide this job into checking drain plugs, couplings or fittings, valves and pumps.

Outboard engines drain themselves, so they are generally free from the dangers of freezing during the winter. Inboard engines, however, must be drained from several places. The water pump itself has one or more machine screw plugs which are removed to discharge the pump's residual water. Before replacing these, and other plugs, work a little clear Lubriplate grease into the threads. Next, check the plugs or petcocks for draining the manifold and engine block, making sure that they are watertight. The carburetor may have been left in place for the winter. If so, the two or more plugs generally present in the bottom of the bowl must be replaced or tightened. The fuel reached the carburetor after passing through a strainer and a fuel pump. These, too, may have been drained and must be made tight again. Now check the fuel tank itself. It may have plugs or petcocks underneath it, used to drain the water which has accumulated. There also may be a hand hole through the top of the tank for cleaning and this is often left open during winter lay up. In any case, drain the tank, and if possible wipe it clean, being careful that no spark or flame is near. The fumes from an empty tank are many times more dangerous than those from a full tank, because they are more thoroughly mixed with the air's oxygen and so have become more explosive. Blow through the tank vent to be sure that no dirt or insects have plugged it. When you think the tank is clean and tight, and secure in its mountings, cap it.

#### *The Water System*

Now return to the engine's water system. Clean and check the intake strainer and make sure that the hose clamps are secure and the hoses themselves are in sound condition. If there is a deionizer, make certain



that the crystals have not dissolved into small grains. These tiny grains can clog or injure your water pump. Discard them, and refill with new, large crystals. On the discharge side of the line, check the nipple which leaves the manifold to see that it is not rusted or leaky. The exhaust is very hot at this point, and nipples do not last many seasons because they are exposed to vigorous corrosion conditions. There may be a small drain plug, here, too, which you must grease and replace. At the terminal end of the discharge line, the water enters the exhaust pipe itself and this is another spot to inspect for rust and cracks. Finally, look at the fitting where the exhaust pipe passes through the hull. It should fit tightly and be free of corrosion.

#### *The Electrical System*

Now, check out the electrical system, beginning with the starting battery. It should be well within its expiration date which will be stamped on one of the terminal bridges. See that the battery is fully charged. If you test it with a hydrometer, it should read 1.250 or higher. If it needs charging, first have the cells tested at a service station to discover if they are all in working order. Be certain that the fluid level is brought ¼″ above the plates of the battery with distilled water. Batteries which have lost their charge will freeze in cold weather, and any battery will run down more quickly in hot conditions, so this check is always important regardless of the climate. Before you connect the electric cables to the battery terminals, make certain that the hookup will run the positive and negative poles in accordance with the directions in your engine manual. Then, clean the poles and connectors with sandpaper and set them up tightly with a wrench. You can then spray them with acrylic paint to prevent corrosion.

#### *The Ignition System*

To give the gasoline engine a fresh start for a new season, replace the condenser. Then, remove and clean all spark plugs and readjust their gaps. If you're in doubt about the proper spacing, use a thickness gauge and set a gap of .025″. Clean the distributor breaker points with a flat file and adjust them so that they break and meet squarely. Check the rotor to be certain that it makes proper contact with the distributor-cap contacts, and see that the cap itself is dry and free from cracks. Clean the contacts of the ignition wires leading from the coil to the cap and from the cap to the spark plugs. If your engine obtains its ignition from a magneto, apply the same technique to it. In either case, be certain that the high tension wires have no cracks in their insulation.

#### *Carburetion*

If your engine functioned properly before lay up, there is no need now to touch the carburetor. Carburetors occasionally suffer from condensation,

from dirt, and from corrosion, but they rarely get out of adjustment for other reasons. We will discuss the carburetor at great length in the chapter devoted to engines.

*The Diesel Engine*

Except for the ignition system of the gasoline engine, most gas and Diesel power plants require similar care. The Diesel engine will have the same cooling system within its body as the gasoline engine, but may often have a fresh-water heat exchanger. If either engine has such a system, you must locate the several plugs carrying zinc which have been inserted to prevent electrolysis. If the zinc has been badly eaten, it must be replaced before the engine goes into commission.

The injectors which deliver oil to the cylinders of the Diesel should be removed and cleaned before the engine is started. If the nozzles of the injectors are worn from the previous season's use, they should be replaced before commissioning.

*General Maintenance*

Finally, put a bit of oil in the lubricating holes for the distributor, the starter, and the generator, and grease the water pump. Check to see that the propeller-shaft packing gland is tight but not dragging hard upon the shaft. Be certain that the fuel tanks and their filler pipes are grounded to the engine or to the keelbolts. And, before you dash home to clean up, change the engine oil, the oil filter, and the oil in the gear box. This dirtiest job can be painless if you purchase a tin of waterless hand cleaner and a roll of paper toweling before you begin. All the common brands of waterless cleaners are good and the cheapest is as effective as the most expensive.

*Oils*

Your attention to proper lubrication is vital to the well-being of all your boat's machinery. Particularly in the case of the engine, it is important that you use the proper grade of oil. Your engine manual will guide you, but you should remember that dirty oil will have a much different viscosity from clean oil and will also contain acid by-products of heat and friction. The letters HD indicate oils with high detergent content. These oils are excellent because they clean the parts they work on and lubricate them thoroughly as well.

There are a number of engine-fuel additive oils that are worth experimenting with because they maintain clean carburetors, ejectors, and valves. Some brand names are Wynn's Oils and Marvel Mystery Oil, which, despite its title, is an excellent product. The addition of oil to the fuel of two-cycle engines, such as outboards, is imperative for the operation of these engines, inasmuch as the oil carried by this fuel is the only lubrication they receive.

Penetrating oils are necessary adjuncts to any boating kit. They very



definitely work, but you must give them time enough to soak through the rust and corrosion. There are several nondripping varieties. There are also excellent corrosion solvents which also have lubricating properties and are available in spray cans.

*Grease*

There are top quality clean white greases on the market, and many are packaged in tubes with nozzles to facilitate applying them. Be certain that the greases you use for water pumps, packing glands, and other submerged fittings are clearly marked *waterproof*.

Lubricants are not products to use haphazardly. Your engine and hardware manufacturers have taken great pains to specify the grade and type of lubricant their machinery digests best. Wherever possible, stay within these specifications.

*Fuels*

The most common fuel for marine engines is gasoline and all the marine grades of gas are of fine quality. Be careful, though, of using automobile gas in your boat. It contains tetraethyl lead, an additive used to prevent engine "knock" because of its low cost. There are other ways of preventing knock, however, and these concern us because the lead and the gas form a gum when they are in the presence of copper tanks and fuel lines. A few years ago it was easy to tell marine gas, because it almost always was colorless. Today there are many colorless fuels among the gasolines, so be sure that you insist upon marine grade.

Some Diesel oils are very corrosive and will etch tanks and fuel lines. Therefore, you must be certain that you purchase only those grades in the range specified for your particular engine and injector.

**Water Closets**

While it may seem a long jump from the engine to the head, they are both overly neglected parts of a boat and need just a little care to keep them active. The fine designer, L. Francis Herreshoff, frequently points out that the most practical head for a small boat is a cedar bucket, and he has had experience with every type of vessel. Unfortunately, few small boats are modern enough to have so dependable a device on board, so we must learn something about its more complicated substitutes.

A marine toilet is nothing more than a pump system with valves so arranged as to first bring in sea water to carry away the waste and to prevent the water or waste from flowing back after it has been discharged. However, if you have ever faced one of these mechanisms when you were heeled over in a sailboat at about forty-five degrees, half-crouching in the gloom of a tiny cabin, while the boat fought its way over Gulf Stream seas, you know how involved a water pump can get.

The real secret of a successful toilet is that it has a pump and valve system so large as to be beyond dirt and corrosion interference. The alternative is to keep the toilet which you have scrupulously clean and in perfect repair. First, inspect the choker valve. This is a pear-shaped or hemispherical valve at the discharge end of the toilet line, designed to open upon pressure from the pump but to close at once against the pressure from returning water. The valve has a long, narrow slit which may have become enlarged through cracking, or clogging from debris, such as discarded match sticks and the like.

In the same manner, examine the two or more flap valves or ball valves which are acted on by the piston's intake stroke. Often one of these valves is on the piston itself. While you have the piston exposed, examine its seal against the cylinder. If the seal is made from leather and has dried out, soak it in neatsfoot oil before reinserting it. If the seal is rubber, plastic, or flax, it may be due for renewal. In any of these latter cases, there is no way to rejuvenate it. Don't oil a rubber seal or valve or it will quickly deteriorate.

There is generally one drain plug to be greased and replaced before commissioning the toilet. After you have done this, overhaul the intake and discharge through-hull valves to be sure they are free. If they are gate valves, like those used in household plumbing, you will be safe in replacing their washers and washer screws each season. Use Monel screws when you replace these parts. The brass screws always eat away in a season or two, and this could cause the loss of your boat if you had need to close the valves for emergency.

### Seacocks

Seacocks require different feeding and care. If the seacock moves smoothly and tightly, work a little waterproof grease into it through the port and leave it as it is. If it is loose, disassemble it, grease it, and put it back together so that it works evenly but stiffly. If it is frozen, spray it with a good corrosion solvent and allow it to remain overnight. Then, with a rubber or leather-faced mallet, tap it very gently from every side until it is free. Disassemble it and treat it as suggested above. When you reassemble the seacock, attach the lever so that it lies in line with the pipe when the valve is open.

The cheapest insurance against sinking is to close all seacocks every time you leave the boat. The reason for this is that many fittings like sinks and toilets are very near water level. When the boat rocks on its moorings, the motion may cause the water in the pipes to pump away air until they create natural syphons. When this happens, water will continue to flow into the boat until it sinks. One means of simplifying the seacock closure is to have a single main discharge pipe for all the outgoing lines, one main take-



up pipe for the incoming lines, and a single valve on each. By closing these valves each time you finish boating, you will cut off all water flow lines, and the activity of the valves will also keep them in good working order.

### Cockpit Scuppers

Most boats built before World War II used lead pipe for their plumbing, and this includes the lines running from the self-bailing cockpit. While lead pipe is very resistant to many forms of deterioration, it fatigues and cracks. There is no lead pipe we will encounter on the boats we are discussing here that would not be better replaced by polyethylene. This is particularly true of cockpit drains where winter debris may clog the lines, permitting ice to crack the pipes.

Once installed, the polyethylene will last many years. It is cheap, light, easy to work with, and you can see at once where it is damaged or obstructed.

### Icebox

The icebox on a very small boat will usually drain into the bilge. As long as you recognize this fact and keep the area around the drain well treated with wood preservative, this presents no danger to wooden boats. A much better idea, however, is to lead the icebox to a through-hull drain, but do so on the side of the boat opposite the box or water will come in when the boat is heeled. If the icebox drains into a sump, there will be a pump to discharge the water. This is generally the bilge pump, or the boat's fresh-water galley pump. It should be overhauled in the same manner as the toilet pump, and you must take care to see that the selector valve separating the lines from your water tanks and sump is in good repair.

Check the interior of the box for the puncture holes often made in the lining by overzealous ice picks. If the box is lined with metal other than stainless steel, you can easily solder these holes, using the proper solders and flux. Stainless-steel soldering is more of a trick, but you can putty the holes with Devcon C, a metal-filled epoxy resin putty which dries as hard as the best solder.

Make sure the drain hole in the box is clear of debris and replace the strainer screen if it is clogged. The ventilation area around the box should be clear. Work wood preservative behind the entire box.

If the interior of the box is in bad shape, strip it of its liner, let the surface dry out for several days, then scrape it clean, sand it to raise the grain of the wood and build a new liner of fiberglass and resin. Details of this type of construction are given in the "Construction" chapter. Not

only will this make a watertight, easily cleaned interior, but it will increase the insulation qualities of the box as well.

## Stove

The simplest galley stove is the Shipmate coal-burning range. The only commissioning needed for it is to clean the flue and to put some coal aboard.

The next most simple stoves are the gravity-fed alcohol burners and the wick-fed kerosene stoves. The former need their tanks cleaned, needle valves wiped on toweling, and fuel connections checked for leaks. The valve stems may require new gaskets every several years. The kerosene wick-burner will require a spare set of wicks and a lot of ventilation. It is not as safe as the alcohol stove because water won't put out its fire but will, on the contrary, spread it by floating the kerosene.

Primus type stoves are very efficient, and we shall consider the alcohol pressure models in this category because air pumps are involved. The primary malfunction of this type of stove is the accumulation of carbon and unburned oil in the nozzles and on the needle valves. The alcohol stoves are immune to this illness, but the kerosene burners are not. If you don't keep them very clean they will not work at all. They will ignite when they are half clean but this is a worse state than the former, because they will drive you from the boat with their fumes and cover your steak with kerosene besides. A slender wire is used for cleaning the nozzle. It must be of a prescribed size, so only use the wire recommended for your stove.

Most of the older models of these stoves are started on alcohol, then switched to kerosene. Carrying the two fuels was so complicated that the Coleman Company developed a fine pressure stove which starts and runs on kerosene alone. If one lives with kerosene long enough he can probably learn to stand the odor, which also clings to one's hands. You may find, therefore, that you can do the job more neatly and safely with alcohol.

The air pumps on these several types of stoves fail for one of two major reasons: the spring-operated closing valve corrodes, or the pump seal goes dry. A little touch of lubricant will straighten out both at once.

If you wish to be friendly with marine insurance men, avoid the subject of gas stoves aboard boats. The only approved ones have the tank installation above decks, with the valve located at the tank. This is such a nuisance that one rarely shuts off the valve. Such practice invariably ends with an explosion. On a large vessel, where elaborate meals are prepared, there may be some excuse for the convenience of bottled gas. However, it is far too dangerous for little boats.

The stoves with self-contained gas tanks are as deadly as their larger counterparts unless you keep the unit stowed in the cockpit all the time. The greatest disadvantage of other types of stoves is that they all require some work to get them started. But, compared to gas, they are safe indeed.



Stoves burning tinned, solid fuel like Sterno are safe and especially clean. You must gimbal them if you plan to use them under way; spilled Sterno makes a vicious blaze.

The more you consider gravity-fed alcohol burners, the more you will see their advantages on small boats. The odor of alcohol does not last; water will put out the fire if you have an emergency.

## Fire Extinguishers

It may be poor psychology to discuss fire extinguishers so abruptly after stoves, but the inspiration comes from a moment aboard a new yawl I had just launched, when I was trying out a stove of my own design. While I fiddled with the valves and burners, a companion, who had just sailed in from France in a tiny boat of his own, sat in the hatchway with an extinguisher and a look of concentration. The stove ignited, finally, and at the same time some several thousand dollars' worth of mahogany and varnish began to blister with the heat. A moment passed, and Marcel remained frozen in the passageway, a look of real interest on his face.

"Don't just sit there—put it out!"

Marcel shrugged elaborately and directed the extinguisher against the blaze.

"All right," he said. "I'll put it out. But—this is the most wonderful stove I have ever seen. All that fire from just one match—"

Marcel attacked the fire with a hand-held carbon dioxide extinguisher, commonly called a $CO_2$ bottle. It is the most effective device for general use on board your boat. Safe to direct against any type of blaze, the $CO_2$ extinguisher is simple to handle and the "snow" it generates will quickly disappear without leaving behind a mess to be cleaned up. Before commissioning your boat, be sure that the bottles are filled. If the extinguisher is portable, take it outdoors so you won't be bothered by the snow and open the valve for a short burst, to be certain that it works. Then take the several extinguishers to a recharging plant (generally your local fire department) and have them weighed and refilled. The only way to check their contents is by weight. About once a year have all your extinguishers examined, but try permanently installed systems before you disconnect them, to make sure that the distributing pipes which carry the gas about the boat are unobstructed. When you reinstall the extinguishers, make certain that the small locking cotter pin is in place so that they cannot be accidentally discharged.

Liquid extinguishers are valuable primarily because you can tell at once if they are filled. Often their valves corrode and the fluid will leak out. For this reason it's a good idea to keep a spare sealed tin of fluid on board. In a real emergency you can pour it directly from the container.

One warning about liquid extinguishers: they are very destructive. Their contents will often eat away varnish, paint and plastics and their odor is irritating in enclosed areas.

Some very fine extinguishers are thin-walled glass bombs containing a liquid. These are designed to break and work automatically when the heat surrounding them indicates fire conditions.

You should have one $CO_2$ extinguisher piped to the engine room. This extinguisher should have its release control located somewhere in the cockpit or forward in the boat, so that you can get as far as possible from the blaze before you release it. Your biggest danger from fire is explosion, so don't hesitate when combustion has started. Put it out at once.

### Bilges

The term bilges generally includes the entire volume of the interior of the boat below the waterline. All dirt and debris seem to work into the bilges of a boat and accumulate there. Quite apart from the philosophical implications of a tidy ship, this accumulation of debris is dangerous because it can interfere with your ability to clear a boat of water in an emergency. Once this debris has become wet it seems to pack together and becomes hard to manage. For this reason, prevention of dirt in the bilges is better than any attempts to cure the condition.

Before launching the boat, and after all carpentry and maintenance work is completed, you can clean the bilges most easily with a vacuum cleaner. This system, which can only be done while the boat is dry, is far superior to any other method you can use once the boat is overboard. Before you vacuum, prod out the limber holes, which are the holes through bulkheads and floor timbers allowing water to pass from one compartment of the bilge to the next. Clean out the bilge-pump intake strainer and valve, and make certain that the drain hole in the bottom of the mast step is clear of debris. If any of the removable floor boards from the cabin sole fit tightly, or if hatch covers from the lockers in the berths are stuck, plane them down a full ⅛″ more than necessary on all their edges. This will assure you that you can remove them quickly if it becomes necessary to pump water from them under serious conditions. The waste products from this carpentry, too, can be removed easily by vacuuming.

### Water Tanks

Most water tanks have easily accessible hand holes in their tops for cleaning and some fuel tanks are equipped in the same way. Use your vacuum cleaner in these areas and leave the holes open for several days before and after you clean so that fresh air can circulate. However, you must protect the tanks from other dirt getting in by fixing a raised cover over the open hole. The best cleaner for scrubbing the inside of water



tanks is detergent and hot water, which you should flush out thoroughly afterwards.

New tanks made from fiberglass-reinforced plastic will have a sweet taste and strong odor for a short time. The only thing to do here is to bake the tanks with heat lamps. Another problem with very new tanks of plastics which are incompletely cured is an exfoliation of growth from the water in contact with the plastic. This must be flushed out, and halozone or iodine added to the water to prevent recurrence. Once the tanks are cured, they will be free from recurrence of this condition. The same growth is also peculiar to new fiberglass and plastic icebox interiors. The plastic, being an organic material, is a favorable environment for waterborne growths during the stage in which the monomere leaves the chemical. The duration of this curing is a very individual thing; you will just have to watch for it and keep your water fresh so the algae won't proliferate.

Water tanks made of copper should be tinned inside to prevent corrosion of the metal. The same applies to fuel tanks made from copper because some brands of gasoline will react with the metal to form sludge. Tanks made from untinned copper can also be treated by coating them with an epoxy resin or polyvinyl which will cure to form a layer covering the inner surface of the metal. These plastics are available from industrial chemical suppliers. The technique in coating is to mix a quantity of the plastic with its activator and pour it in the tank which is then capped and turned about in all directions to distribute the film of plastic over the surface. You must keep turning the tank constantly until the plastic is set or it will all accumulate on the bottom because of gravity.

Many tanks made from galvanized iron only have that protective coating on the exterior of the tank. Often, a tank which appears new from the outside is rusted almost to destruction within. Such tanks can have their lives prolonged by a plastic coating such as we described above. However, this is a stopgap measure because the rust already contains moisture and air which permit it to go on oxidizing. The real answer, here, is replacement of the tank and you can quickly build your own from plywood, lining the interior with fiberglass-reinforced plastic. More detailed directions are given in the chapter on "Construction."

Monel metal makes the best metal tanks because it is highly resistant to corrosion. Monel tanks are the best of all for gasoline because in case of fire their resistance to heat helps delay the danger of explosion.

### Commissioning the Rigging

Because there is an entire chapter devoted to rigging, here we only touch upon the steps necessary for getting the spars and gear into place aboard the boat, and keeping them there until we are ready to tune the boat.

The spars must be put in good shape each season or they will soon break down from weathering and fail under their sailing load. While the spars are out of the boat, build a good finish of paint or varnish, particularly over the very top of the mast and the upper surfaces of the spreaders, paying particular attention to the wood inside the clevis where the halliard sheave works. Next, clean out the drain hole in the foot of the spar and soak the end grain of the mast in preservative. Any cracks or failures of the glued joints should be repaired according to the detailed instructions in the "Rigging" chapter. Check all mast and boom attachments for loose fastenings and repair these before the rig goes into the boat.

Once the spreaders are in place, be careful not to bend or twist them or their fittings. Spreaders which are completely free to swing in any direction are the safest and the strongest. They are easily made from inexpensive stock. See the illustrations in the "Rigging" chapter. Now, before attaching the rigging, is a good time to put in new bulbs for the masthead and spreader lights. Test these bulbs before you seal them up to be sure they are properly socketed. It's a long climb up to the top of the mast with a new light bulb in one hand.

### *Halliards and Rigging Wires*

It will be easiest to rig the halliards before you put the shrouds and stays in place. Attach the pairs of wires together to make it easy to check their clevis and cotter pins, first on one side of the spar, then on the other. Always tape the cotter pins after they have been bent, so as to protect your sails from any snags. Where the upper shrouds pass through notches in the spreader tips, be sure they rest against a seat of soft metal, like copper, and have a second band of metal outside the notch to retain them. It's a good idea to wrap the spreader tips with nonchafe tape. Plastic electrical tape is good for this and it won't leave stains on your sails.

When everything is in place, even the little halliard for the flag, tie all the lines and wires to the spar with occasional turns of cotton thread or yarn. Use the weakest stuff you can obtain and wrap it sparingly. Once a turn of thread is out of reach it becomes either very strong or very weak depending on its mood. These wrappings can be surprisingly difficult to break loose from the deck.

### *Stepping the Mast*

The shipyard will loop a big rope eye about your mast so they can raise it over your boat. First you must make sure that they loop this underneath your rigging wires, or the loop will compress them deep into the wood. Next, you must attach a downhaul from the loop to a stout winch or cleat on the mast. This is both to keep the loop from breaking off your spreaders, and to retrieve it to deck level so that you can remove it from



the boat. Stepping the mast in a small boat is no problem at all, but with a boat that is big enough for the mast to have some weight, the problem becomes more serious. If the day is very windy, or the water in the masting basin is rough, you had best consider delaying until things moderate. A mast weighing fifty pounds, hanging vertically above the deck of a pitching boat, can perforate that deck in several spots before it hits the hole it is designed to enter. Then, while it is looking for the mast step down below, it can damage the planking in the same manner. Even in good weather, if your boat is fairly large, have a trustworthy man to watch the spar on deck while you attend to it below.

When the foot of the mast is properly seated, attach the headstay and the lower, after shrouds as quickly as you can, and get the boat clear of the masting area. This is for its own protection, because the tackle which handled the mast will be swinging in the wind, and the mast itself will be moving in the boat.

An unstayed mast, or one with a single headstay, such as a catboat, requires wedges to be placed as partners between the spar itself and the material of the deck which is cut away for the mast. Tap these wedges into place very lightly, then cover them with a waterproof coat which will ordinarily be taped to the mast and to the collar of the deck. This coat is a conical sleeve of waterproof fabric such as coated nylon and is a vital part of masting. It prevents fresh water from flowing down the mast and rotting away the deck and the mast step. The wedges which space the mast away from the deck should never be forced into place. It is common to see inexperienced people and even boatyard workers driving these partners down with a mallet. This practice will generally split the mast, will always split the deck, and will do so in such a subtle way that you will not discover the damage until rot has begun.

Extreme tightening of the shrouds and stays is a practice that is as bad as driving the partners in tightly. When you make the rigging tighter than necessary, you put a serious initial load upon the mast and boat. More spars have broken because they were rigged too tightly than because of too little initial tension. Take up the slack from the wires a little at a time, first on one wire, then on its opposite. If you set one side of a pair of wires tight, then go to the other side to straighten the spar, you will double or treble the load. To tell accurately when the spar at last is straight, sight along the track which carries the sail, keeping your eye very close to the track and down near deck level.

When everything is in place, see that each fitting is properly secured with cotter pins and that these pins are wrapped with tape. The turnbuckles must be locked with nuts or by wiring. Lashing them with wire is the only really positive protection for them.

### Ground Tackle

One evening, sitting in the cockpit of my boat at anchor in a cove in the Bahamas, I was arrested by the sight of a native fishing smack roaring for the beach with little wind but a lot of tide. The helmsman suddenly shoved the tiller hard alee to bring the boat around, but nothing happened. "Let go, mon," he hollered to the bow where a sailor wrestled with an enormous, rusty anchor tied to a two-foot piece of rope. "I cahn't, Cap'n. De rope's too short!" The Cap'n cupped both hands around his mouth and bellowed like a bull, "Never mind de rope . . . just t'row de anchor."

As our Bahama friend indicated, when you want anchor you want it right away, but you also need enough rope to reach the bottom with it.

### Anchors

For use on a wide variety of bottoms, the Danforth and Benson anchors are the best. They stow flat on deck or in a locker, are very easy to clean, hold as well as any other type and better than most, but, best of all, they are always ready the moment you need them. An improved variety of both these anchors is available from Rosselles, Inc., at 126 Southwest Second Street, Miami, Florida. This new type of anchor has the bonus advantage of a tripping device for freeing it from rocks and bottom obstructions, plus a friction link so the anchor cannot trip itself when the boat drifts around in a tideway.

The traditional anchors such as the yachtsman's kedge are quite dependable, but you must purchase the type which has very sharp flukes. The main disadvantage of these anchors is that one fluke always projects up from the bottom so that the boat, circling about the anchor with the winds or tides, can loop the anchor line around this fluke and pull the anchor free. The smaller, but nonetheless important, disadvantage is that these anchors require time to assemble before they can be lowered. There are moments when saving time in anchoring may save your boat or your life.

#### *Anchor Line*

The best investment in anchor line is nylon rope. The "Appendix" at the end of the book will give you some ideas of diameter and length for different boats, related to the proper anchors for the work. Nylon rope is more expensive than other types of natural fiber, but it is rot-proof, elastic, to reduce the load on anchor and on boat, and extremely strong. It runs out smoothly, is pleasant to handle, and can be stowed in less space than manila of the same length. Since you can purchase nylon rope at war surplus or at second hand, it is archaic to consider the older materials except as mooring lines.



### Moorings

Manila rope is good for mooring lines provided that you keep it new; never more than a season or two of age. Its use here, in comparison to nylon, is measured in terms of chafe, accident, and soilage. Around the dock, where damage to the lines is likely, manila can be replaced at small expense. At a buoyed mooring, however, the arguments for nylon come back again in all their strength.

The buoyed mooring is a special case and is explained in a table in the "Appendix." However, in commissioning the boat it is essential to check the ground mooring, its chain and shackles, and the attachment of the pick-up buoy and its line. Renew the pennant, which runs from the chain to your boat, every season, To facilitate picking up the pennant, a buoy has been devised which is made of a fiberglass-covered float having a fiberglass vertical rod, like a fishing rod. This vertical rod is easily reached from the deck without the need of a boat hook and is a very good investment for the boatman whose children act as crew. There is little danger of a caught buoy doing damage, but a boat hook which has snagged the mooring when the boat is under way can splinter and become a dangerous weapon.

Don't put your boat on a mooring unless you know that the mooring is safe. An unwired shackle or rusted link of chain could cost your boat plus all the other boats it might damage on its way.

### Launching

The discussion of rigging and ground tackle may have transported you to the high seas without the intermediate step of launching. However, before you put your boat overboard, it was necessary that you have some means of tying it up. Now, before the boat goes in the water we had best consider a few operations which accompany the act of launching.

Generally, bottom paint is applied to the boat very shortly before she will go into the water. In distributing the antifouling paint to get proper protection, it is necessary to move the shoring about the boat's cradle, one unit at a time. Now, before the boat begins to move, make a final check to see that all the shoring is in place and properly wedged and nailed so that it cannot move. In doing this, be careful not to scratch the bottom paint or the boat will certainly foul in that spot.

If you drained your tanks of fuel and water as you should have, leave them empty until the boat is overboard and you have won the race with water coming through the unswelled planking. The tanks may give you the buoyancy you will need in case the leaking gets out of hand.

If the seams appear to be tightly filled with compound, and the boat has not been out of the water more than a year, she ought to leak very little. Fiberglass and metal boats will not leak at all; they have no seams.

You can launch them any time you wish, only checking for drain plugs and through-hull fittings, just as you would in a wooden boat. Now, as your boat settles in the water, leave the floorboards open and stand by the primed bilge pump. Don't permit the boat to leave the cradle until you are satisfied that the water is coming in more slowly than you can easily pump it out. If the leaking begins to gain on you, haul the boat again. Then put a little water in the bilge and hose the boat down for several hours on the exterior. Never fill the bilge with water when you are hauled. The boat was made to take pressure from outside, not inside, and you will burst the planking or the hull. After two or three days, launch again. If the boat still leaks badly, watch when she's being hauled out and see where the water runs from the hull. You may have to caulk or putty, here, or make other repairs.

Swelling can take place quickly. In a cedar boat, the leaking may be done with in a day. But in boats of hardwood or boats of heavy scantlings, a week may pass before the leaking stops. If it continues throughout the season, track it down and fix it. No boat has to leak. That concept went out with other old wives' tales. But never turn your back on the boat until you know she's safe to leave.

CHAPTER 4

# The Engine

In chapter 1, "The Right Boat for the Job," we discussed the relative merits of power plants. Here we shall consider maintenance, repairs, and trouble shooting for both inboard and outboard engines.

It is almost always possible to trace engine failure back to improper care and adjustment at the hands of the owner. Your engine's general health pattern is formed right at the breaking-in period.

When the engine is first put into commission, there are several particulars that must be checked. The most important of these is lubrication. The greatest difference between inboard and outboard engines is that the propeller unit is an integral part of the outboard and has lubrication problems that are much more involved than those concerning the inboard engine. Also, most inboard engines operate at relatively low speeds and are lubricated from a reservoir of oil which is separate from the fuel system. Outboard engines are mostly high speed and in order to lubricate them oil is mixed directly with the fuel. Most manufacturers recommend an oil change after the first fifty hours of operation of an inboard motor. For outboards, this time is set automatically because of the oil-fuel mixture and only the lower unit which contains the propeller and its gears is greased or oiled separately. Your outboard engine manufacturer will have indicated the type and viscosity of the lubricant.

## OUTBOARD MOTORS

The original purpose of the outboard motor was to provide easily

portable power for boats ordinarily propelled by sail or oars. The early units were quite inexpensive and had great appeal for the public. Their popularity started a trend which led to boats that could be towed by trailer from the owners' homes to water and this convenience made maintenance costs and depreciation very small. However, when the demand for outboards grew, the available size and power of the motors increased all out of proportion so that today we find large, extremely powerful outboard engines dominating the field. In order to develop their power, most outboard engines work on the two-cycle principle. This is a term used to describe the number of movements each piston requires in order for it to fire. The piston of a two-cycle engine makes two movements for every fuel explosion. The piston draws in fuel, compresses it in the cylinder, then the sparkplugs ignite the fuel, which drives the piston outward. When the piston has moved a great enough distance, it exposes an exhaust hole through which the fired gas is discharged and that is the end of the second cycle.

**Outboard Lubrication**

Because the two-cycle principle of the outboard motor does not require auxiliary valves, the motor has no circulating oil system. The oil that you mix with your fuel is consumed at the same rate as the gasoline is burned, and the mixture of oil and fuel is used to lubricate the piston rings and cylinder walls. Outboard engines run hot because they fire so frequently; also, the heavy oils used to lubricate them tend to foul the sparkplugs. To avoid these problems, under no circumstances should you use an oil different from the manufacturer's recommendations. The answer lies in proper sparkplug adjustment and correct mixture control, each of which will be discussed under the heading "Fuel Systems."

The lower unit of the outboard, containing the propeller shaft and gears, may be lubricated by oil or by grease. Oil lubricated units usually have a top and bottom plug. For conventional filling of these units, open only the upper plug and fill to its level. The lower plug in such cases is used for draining. However, there are some lower unit oil lubricants which are packaged in tubes with nozzles designed to fit the lower plug hole. These tubes are rolled up with a key and inject the oil under pressure, so you must remove the top hole from the unit before the oil will enter. Once the top hole is open so that the entrapped air can escape, you can quickly wind the key on the oil tube until the lubricant flows over at the upper hole.

Grease-lubricated lower units should be filled from top to bottom. Here, you will have to loosen both plugs and inject the grease through the top hole. Force in grease until the unit is filled and the grease begins to flow out through the bottom hole.



There are several shaft seals on the lower unit and, as they wear, grease or oil will begin to escape and water will enter. While the proper repair for this is replacement of the seals, sometimes this is not possible; you must be particularly careful to grease your units several times each season.

**Outboard Ignition**

Conventional outboard ignition is accomplished by a magneto operating through breaker points to time the delivery of the spark impulse to the proper cylinder. Failure of the ignition system to spark can be traced from the plugs, through the ignition wires, and at the points and the magneto. Because it is simplest first to check and see if the electricity is getting to the plugs, it is easy to locate the end of the ignition system which is faulty. Remove a sparkplug wire, wipe it dry and, holding it by the insulated portion, position it about 1/8″ from the motor block or head. Pull the flywheel around while maintaining the wire in position and see if a spark jumps the gap. If the day is bright, you may have to create some shade with your body for the spark to be visible. If you find a spark, everything is all right so far, and you must next check the plugs. You will have to pull these, every one, from the engine, reattach the ignition wire, ground the side of the plug to an area of the engine block away from the sparkplug holes (to avoid any chance of explosion of the escaping gasoline) and pull the flywheel around.

Generally, it pays to clean the plugs each time you test them. This is easily done with a sanding board of fine grit, after which the gaps in the plug must be reset. You should have a thickness gauge for this job. The usual gap is .025″, and you establish it by gently bending the electrode on the side of the plug. The center electrode is too fragile to withstand bending because it is set in a ceramic. If you discover that a plug is cracked or badly pitted, throw it away and substitute a spare of the same designation.

If, when you held the ignition wire against the engine to see if you could pull a spark, you drew a blank, your trouble may range from ignition wire through the magneto itself. Examine the wire for cracks or for caked salt on the insulation. Either of these causes could prevent ignition. Check the terminals, or ends, of the wire. If they are not clean and bright, touch them up with extra-fine sandpaper or with a sharp knife. If you still get no spark it means that you will have to pull the flywheel from the engine to get at the basic system.

The magneto itself can fail for a large number of reasons. The most common is moisture, which drains the electricity before it can be built into a sizable charge. The next reason for failure is improper contact of the points of the magneto. Moisture can be removed by baking the magneto in a warm oven. 150° F. will generally do the job without damaging the insulation, but you should watch and sniff for indications of burning at

any temperature above 120°. At the slightest warning of burning, you must draw the magneto from the oven. The points of the magneto should be filed to make clean, solid contact. Often they can be scraped clean of corrosion just by touching them up with the blade of a very sharp knife. The only danger from this operation is in making the points irregular, in which case they will pit badly and soon fail again.

### *Fuel Lines, Tanks, and Carburetors*

Dirt and water are the worst enemies of the fuel system, but they are also the most easily guarded against. A proper strainer in the fuel line is absolutely necessary to any engine. Avoid the ceramic filters because these eventually will discharge bits of their own material into the stream of fuel. Perhaps the best filters are the automotive ones with a brass replaceable strainer unit. For outboard motor use, you can purchase strainers of the kind used on private aircraft. These have a spring-loaded drain valve in the base, enabling you to draw off water before you start the engine, or at any time during its operation. (It is important not to use such systems on inboard engine installations, as they are a serious fire and explosion hazard when enclosed in the bilges of a boat.) In cases where large amounts of water have entered or formed in the fuel tank, it is possible to add ethyl alcohol or acetone to the tank where it will combine with the water and with the fuel so that the total mixture is combustible. About one pint of alcohol will handle all the water which would form in a twenty-five gallon tank under normal conditions.

If your engine fails, and you find, upon disconnecting the fuel line, that gas is getting to the carburetor but does not get through it, you can quickly get the main jet open by unscrewing the entire valve insert from the carburetor. Usually the escaping gas will at once clear the obstruction but in a stubborn case it may require gentle probing with a bit of fishing leader wire. Before pulling off the valve insert, count the turns required to seat the valve gently, so you can be sure that it is at its proper setting when you reassemble the unit. As outboard motor carburetor adjustments are generally indicated on the cover of the engine, there is no problem in making power adjustments for different loadings. However, an occasional starting trouble with outboards results from flooding the carburetor with gas. This is due to overchoking the engine to prime it, or, sometimes, to opening the needle valve beyond the necessary number of turns. In a flooded state, the carburetor cannot mix enough air into the gasoline to explode it, but the cure is simple and quick. You must close down the needle valve, the main fuel valve ("shut-off" valve), open the choke so air can pass freely, and turn the engine over several times so that the excess gas is thrown off from the cylinders. After you have done this, you



reset the valves to starting position and follow your regular sequence of steps.

### Outboard Cooling System

Despite a lot of advertising to the contrary, aluminum and its alloys are still corroded by salt water. It is very important to flush the salt thoroughly from the cooling system of an aluminum engine after every use. You can do this either by running the motor in a drum of fresh water or by washing the salt out with a hose. When the engine has been thoroughly flushed, expel the excess water by turning the engine over several times out of the water and with the ignition switch "off." If the water pump has a drain plug, withdraw it and let the water run from the pump as well.

## INBOARD MOTORS

In contrast to the outboard, the inboard engine is usually four cycle, and develops its power at lower speeds. The four-cycle system is far more economical than the two cycle and grants the engine a longer useful life. The steps in a four-cycle engine are these: when the sparkplugs fire the compressed gas between the piston and the cylinder, the piston moves down, driven by the explosion of the gas. As the crankshaft of the engine continues to turn, it raises the piston again, a valve is opened in the top of the engine and the exhaust gas from the explosion is discharged. Then, as the crankshaft continues to turn, the piston begins to descend again in the cylinder and the second valve is opened letting in a mixture of fuel and air. The crankshaft, still turning, closes all the valves and drives the piston up again in the cylinder. This compresses the mixture of fuel and air. Just as the piston reaches the limit of its travel the sparkplug fires and the four-cycle series begins again. The valves of the four-cycle engine are controlled by cams driven by a special shaft and the entire valve system is lubricated independently of the cylinder and piston system.

### Inboard Lubrication

As with the outboard engine, the most neglected aspect of inboard engine maintenance is proper lubrication. The worst offense an owner can commit against his engine is improper attention to oil changing. Heat and friction in the engine, combined with the combustion of fuel and the formation of exhaust waste products, contaminate the oil with bits of metal, dirt, carbon, water, fuel, and the acid generated by the addition of these corrosive products to the whole. While the engine of today is usually equipped with an oil cooling and filtering system, still the manufacturer's recommendation must be strictly observed. Detergent oils have

a cleaning and emulsifying action which makes them more protective than nondetergent lubricants and they should always be used in your engine. Be sure, when changing oil, that you replace the oil filter at the same time. Take particular pains to drain off as much of the old oil as possible. This is always easiest to do when the engine is still hot from running. Some engines have built-in pumps for discharging the old oil. On others, an oil sump pump must be inserted through the dip stick hole and the old oil pumped into a paper bucket or tin for disposal. Occasionally, one comes across an engine which has an oil drain plug in the bottom of the pan. The engine bed construction may make this inaccessible for regular use but, if it is possible to use it, it is the most convenient means of all.

The water pump on an inboard engine must be packed with a proper waterproof grease, and the grease cup must be tightened regularly. The propeller shaft, too, will require lubrication where it passes through the packing gland bearing or stuffing box. Here, too, waterproof grease is necessary.

Many reverse gears and reduction gears demand separate lubrication attention. They will require regular filling and oil changes, just as the engine itself does, and they also may have separate oil cooler and filtering systems that you will have to maintain. These gear units are generally not made by the engine manufacturer. They are accessories to your engine although the instructions for maintaining them are usually enclosed in your engine manuals. Access to these gear boxes is almost always through the top cover plate. To drain the oil from a gear box which has no drain plug, insert the intake hose of an oil sump pump into the box at the end nearest the engine, where you will have much the most room to work. When refilling gear boxes, it is important not to exceed the oil level recommended by the manufacturer. You should check your engine manual for this information and for recommendations for the correct viscosity of the lubricant to use.

### Inboard Engine Ignition

Inboard ignition systems generally start with the battery. This unit is most subject to the neglect of its water level being allowed to drop below the top of the plates. This level should be maintained by distilled water, covering the tops of the plates by at least $\frac{3}{8}''$. The battery should always be kept clean, dry, and well charged. A fully charged battery will yield a hydrometer reading from 1.250 to a peak of about 1.280. Dirty or corroded battery terminals will often make a fully charged battery act as though it were nearly exhausted. You can clean the terminals with fine sandpaper, at the same time cleaning the fittings of the battery leads. Some good anticorrosion electrical terminal greases are available which help to keep proper circuit contact. Be particularly careful to maintain fully charged batteries in cold weather. Partly discharged batteries are highly susceptible to damage from freezing.



The most common starter failure results from the Bendix Drive sticking. This is the mechanism by which the starter gear teeth engage the teeth in the flywheel, and it is necessary to lightly lubricate this shaft with oil. The contacts between the commutator and the brushes of the starter may wear or gather dirt, in time. Commutator bars can be cleaned by holding a bit of clean, fine sandpaper against them while they turn. Never use emery cloth for this job. It will leave a deposit from its backing which interferes with the conduction of electricity.

The generator functions to replenish the electricity drawn from the battery when starting the engine. Most modern generators have an automatic voltage regulator so that if the battery is well charged, the ammeter indicates very little generator current. If the battery continually runs down, and the regulator has been adjusted to charge at its maximum capability, the generator may be running too slow. This is frequently the case in a boat with too big or too steeply pitched a propeller, which does not allow the engine to develop its normal r.p.m. A generator sometimes will lose strength during a lay-up period and when the boat is recommissioned the generator fails to charge. You can restore the field strength by running the generator while you hold the cut-out contacts closed for several moments, then releasing them. Alternatively, the generator itself may be defective, which is a job for the generator specialist.

If your engine has a magneto, it can be treated as described in the section "Outboard Ignition." Normally, however, four-cycle engines today handle their ignition through the distributor. The electricity passing through the distributor is pulsed by the breaker points to the spark coil where it builds up a magnetic field. When the breaker points open, the magnetic field collapses and there is a surge of high tension current delivered to the sparkplugs. In order for this delivery to be "clean" and full strength, the breaker points must be in accurate contact with one another and have proper gapping. These points can be dressed with a fine, flat ignition file, and their gap set in the open position by adjustment of a retaining screw or by bending the rubbing block which makes contact with the distributor cam. Check the gap with a thickness gauge for the setting recommended in the engine manual. The cam itself should be kept lightly coated with grease and the distributor shaft lubricated.

The distributor is rotated slightly in its mounting to time the engine. This timing is the actual adjustment of the moment of spark delivery in relation to the position of the pistons and valves in the engine. An engine which sparks too early in its cycle may lose 25 per cent of its available power and overheat badly as well. An engine which fires too late can lose about 5 per cent of the available power and will generally knock.

The first check that you can make for the proper timing is by static setting. This is a visual check that you make by rotating the engine's flywheel until a key piston is in the fully compressed position. At this point, contact in the distributor or magneto should be closed to deliver a spark. The data for your static setting is obtained from your engine manual, which will refer to the cylinders by number. The numbers of the cylinders are cast right into the head of the engine in almost every case. If your engine is the rare one which does not carry any markings, count the cylinders from the flywheel end of the engine, the one nearest the flywheel being number one.

The second method of checking timing is used for your final adjustment. For this, the engine should be run under full load and at full speed. Rotate the distributor to advance the spark until the engine speeds up, then rotate it the other way so as to retard the spark until the r.p.m. drops. Somewhere between these points, the engine will sound its best and is in proper time. If the engine knocks at the setting, retard the spark until the knock just stops.

We have already mentioned the coil, where electricity is built up to high tension current in engines using distributor ignitions. The coil is always matched with a condenser, the function of which is to absorb the surges of electricity in order to prevent them from arcing at the points of the breaker. When the condenser does not properly perform this job, the points will soon pit or blacken. This symptom is a good check for the condenser, and it is advisable to carry a spare coil and condenser set on board the boat at all times for your engine. When either unit fails, play safe and replace both.

### *Fuel System*

Earlier in this chapter we discussed the fuel system of the outboard motor. Most of the things applying to the outboard hold true for the inboard engine as well. Here we shall consider the more salient differences.

Fuel tanks for inboard engines are generally built into the boat in relatively inaccessible places. It is therefore important that these tanks be designed for the greatest safety and the least maintenance. The paramount danger from any fuel tank is leakage. This can be obviated as a danger in new tank installations simply by making the tank in such a way that it has no openings except at the top. The filler pipe, vent pipe, and fuel line can all enter through the top of the tank, and filler and fuel tubes can be carried down inside the tank to within about one inch of the bottom. When it becomes necessary to empty the tank completely, drop a plastic hose through the filler pipe and siphon off the last bit of gas. Alternatively, the fuel line can be passed through a brass compression fitting, so that it can



be lowered the final inch, right down to the bottom of the tank, in times of emergency when you need that ultimate drop of fuel.

Monel metal makes the best tanks. An almost as good substitute is tinned copper, but do not use plain copper for, as discussed in the section on cleaning tanks in Chapter 3, some gasolines will form a dense sludge in its presence. Iron tanks rust and they are therefore entirely unsafe. Perfectly satisfactory fuel tanks can be made from fiberglass-reinforced plastic, but for gasoline engines it is less safe than the truly noninflammable metals. Regardless of the material used, tanks should be strong, well baffled, and securely fastened to the boat. They should be square or rectangular in general shape, so the fuel cannot escape from the area of the fuel line.

There is a tendency for boatowners to set their carburetors so that the fuel to air mixture is on the rich side. This seems to result from the desire to obtain quick starts. However, this type of setting fouls the plugs, is very uneconomical, and sometimes can contribute a lot of water to the gasoline, because the fuel acts as a coolant in the carburetor throat and condenses water from the air. Make a better adjustment at the main jet-needle valve when the engine is warm and the boat is running at cruising speed. Simply close the needle valve a little at a time until there is a drop in r.p.m.

To adjust for best power, run the boat at full throttle, then open the valve until the speed drops. Close back until the drop ceases and you will be at the maximum power adjustment, although you will have poor fuel economy. Never go to the leanest possible mixture, however. Remember that the fuel is a coolant and, at greatest economy, there isn't enough fuel present to properly cool the valves in the presence of the reduced rate of combustion. As a result, the valves may warp or burn out and you will have a major repair job on hand.

After you have set the main jet-needle valve where you want it, adjust the idling valve until the engine runs most smoothly. Then tighten the packing nuts at each screw-valve and leave the carburetor alone.

The float level of the carburetor is adjustable according to directions in your engine manual. It is important that there should be no excess fuel in the bowl. Dribbling into the bilge, this can be a fire and explosion hazard. Besides controlling the float level, it is important that the carburetor have a big, clean flame arrester and an overflow pan to catch any excess fuel and pull it back through the carburetor.

### Inboard Cooling System

In the "Testing" chapter of this book we pointed out that a cool engine is by no means an efficient one, either from a fuel, power, or longevity viewpoint. On the other hand, if the engine runs in salt water, a serious

problem may arise from salt deposits in the water jacket at high temperatures. Deionizing devices which keep this salt from precipitating out are excellent accessories to any engine. Their only risk lies in the possibility of old, tiny crystals escaping from the unit and injuring the water pump or lodging in the engine. A big, proper filter will avoid this danger and is an important engine protection in any case. The best and cheapest deionizer is the Sudbury Aquaclear Feeder.

Carrying the cooling water out into the exhaust is a standard bugbear, particularly on sailboats where there might be a danger of water backing through the manifold and into the valves. There are two ways to prevent this: the first is by carrying the exhaust pipe up higher than the manifold, then slanting it back down and introducing the water on the exit side. The exhaust can run "hot" on the uphill side of this riser, or you can have your machine shop braze a large piece of hard copper tubing outside the exhaust pipe (which, in this case, should also be a hard copper tube) reaching from the manifold nipple to the top of the rise. A pair of nipples, one at the top and one at the bottom of this device will allow you to watercool the exhaust. Introduce the water at the bottom of the jacket and draw it off at the top. From this point aft, steam exhaust hose makes a good flexible pipe and helps deaden any engine noise.

The second way to avoid the danger of water backing into the engine is by the use of a large gate valve at the most accessible part of the exhaust pipe. This should be an additional accessory to the waterjacketed riser in any boat which will run in really rough water; sometimes a following sea can surge through the exhaust pipe with enough pressure to climb right up the riser.

## Table for Trouble Shooting

*Cannot operate starter*

1. Dead battery.
2. Poor electrical connections. Check for dirt and tightness.
3. Stuck or broken Bendix.
4. Engine frozen. Possibly water in cylinders.

*Engine turns over but won't start*

1. Weak battery.
2. Defective ignition switch.
3. Water in ignition system.
4. Flooded engine.
5. No fuel; line clogged, carburetor clogged, valve closed, empty tanks.
6. Dead coil or condenser.

*Backfiring*

1. Running out of fuel.
2. Poor adjustment of mixture or timing.



3. Sparkplug wires crossed.
4. Dirt in carburetor.

*Misfiring regularly*

1. Damaged wiring or distributor.
2. Damaged valve(s) or valve spring.
3. Damaged engine-head gasket.

*Misfiring irregularly*

1. Dirt or water in fuel.
2. Sticking valves.
3. Very rich mixture.
4. Ignition wiring loose or corroded.

*Engine knock*

1. Incorrect fuel octane.
2. Incorrect plugs; dirty plugs.
3. Damage to cooling system.
4. Spark too advanced.

*Oil pressure loss*

1. Broken oil line, or pump, or pump coupling.
2. Clogged line or filter.
3. Wrong grade of oil.

*Engine suddenly stops*

1. Out of fuel.
2. Obstruction in fuel system.
3. Coil or condenser fails.
4. Distributor rotor fails.
5. Breaker points fail (broken spring or fusing).
6. Wire vibrates loose.
7. Engine overheats and seizes.
8. Generator fails.
9. Ignition fuse fails from overload.

## Engine Winter Lay Up

1. Drain oil from warm engine. Replace filter. Repiace with clean oil.
2. Pull sparkplugs and pour one ounce of oil in each cylinder, turning engine over to distribute the oil on the cylinder walls and piston.
3. Clean and replace sparkplugs.
4. Completely drain cooling system and refill with antifreeze mixture even if engine will remain out of commission; this helps prevent corrosion.
5. Completely drain fuel system and carburetor.
6. Plug exhaust opening.
7. Remove batteries and keep them on low charge all winter.
8. Coat metal parts of distributor with rust preventative grease.

9. Wirebrush exterior of entire engine. Spray thin coat of paint to protect it through winter.
10. Lubricate switches and coat terminals with anticorrosive grease.
11. Unbolt propeller shaft coupling. Remember boat will change shape during lay up.
12. See that inside of battery box is dry and clean. Acids from the battery can continue to do damage through the winter.

RECOMMISSIONING

1. Check oil level.
2. Pull exhaust plug.
3. Fill fuel tanks and check fuel system for leaks.
4. Install batteries, fully charged.
5. Check engine-bed bolts.
6. Check inside distributor.
7. After boat has swelled, check propeller-shaft line-up and tighten coupling.
8. Check reverse gear adjustment.
9. Warm up engine at low speed.
10. Check out engine as in chapter on "Testing the Boat."

## THE ENGINE ROOM

The layout and design of the engine room can contribute as much to the quiet, trouble-free operation of the engine as the quality of the machine itself. Most of the maintenance neglect suffered by engines results from installations which are inaccessible to the owner. The owner's inability to check the oil level means that often there will not be enough oil in the crankcase.

There are two alternate ways to gain engine access. The first way lies in the hands of the designer and builder. The area around the engine should be large enough so that all parts can be reached for care and adjustment. The second way lies in the engine itself. If you or your designer have picked a machine that can be readily serviced, and is small enough to leave some space around it, you will be tempted to pay closer attention to the motor. Particularly, you should be able to swing a wrench on any fitting from the shaft coupling to the flywheel bolts. If gaining this access means you must cut extra hatches, by all means do so, even though you may have to place extra support work under the cockpit sole.

Color, too, is an important aid to proper engine maintenance. A fresh coat of light colored paint invites you to keep the area clean and aids both your visual approach to the motor and your ability to find tools and parts as you lay them down. Color, moreover, is important as a heat insulator. Light grays, blues, greens, and, of course, white, do not reradiate heat from the deck and hull into the engine area. But these colors must, indeed, be light. A dark green, for example, is capable of transferring considerable heat. Reds and browns should be avoided at all costs.



Ventilation of the engine room is an extremely important aspect of design. It is almost impossible to blow air into an enclosed place, except under great pressure. It is relatively easy to draw it out. So, if you provide two or more ventilators with generous water traps, leading to the deck, you can keep the area free from mold, rot, and dangerous fumes. Ventilators should lead to the low part of the bilge, as fuel fumes are heavier than air and tend to settle. Mechanical blowers, even though they are spark shielded, are dangerous. Use natural air flow if it is at all possible. Remember that you cannot ever have too much ventilation, but that it is easy to have too little.

Sound insulation of the engine room is another important contribution to pleasure in large-engined, high-speed boats. A very good waterproof-insulating composition is Homosote. It comes in thick rectangular sheets and can be nailed in place or glued to unpainted surfaces. Its sound-absorbing qualities are excellent and it also reduces vibration of the panels over which it is attached. Alternatively, there are low density coatings which can be painted or sprayed. Some of these use ground cork as a medium and are particularly effective in metal boats. Boats of fiberglass-reinforced plastic can be readily insulated by either of the above methods, or by cementing battings of fiberglass-insulating material against the surfaces of the engine room.

Further sound reduction can be accomplished by flexible couplings in all pipe lines and by truly firm engine mountings. Often the sympathetic vibration of a single unit, such as a steering cable pulley, can make a noise all out of proportion to its size. These sounds must be hunted down and arrested on an individual basis. A major noisemaker can be an improperly faired propeller aperture. All areas in which the propeller works should be knife edged as far as is possible. The propeller itself may be unbalanced, or improperly shaped for its speed, and this, like improper shaft alignment, can make an enormous amount of sound. A loose rudder can vibrate in the propeller wash, making a noise which is amplified by the water surrounding the hull itself.

Finally, the fuel and water tanks will often vibrate and resonate, particularly when they are only partly filled. The proper answer lies in the tank design itself, but a stopgap answer may lie in wrapping the tank with insulation material.

### Engine-room Fire Fighting

The most serious hazard of the sea is explosion, which is almost always the result of improper maintenance. Fuel lines must always be watched

for leakage. The bilge itself should be sniffed for fumes before closing the main switch aboard your boat. A small amount of gasoline is capable of an explosion equivalent to a sizable amount of T.N.T. and there is no truth to the myth that a cigarette is not hot enough to set it off.

The most effective material we know today for fire fighting is carbon dioxide gas. It is simply not intelligent to use any other material in the light of present technology. The method is simply to pipe the gas into the engine room, laying the pipes so that they deliver a great cloud of the gas all around the engine and tanks as quickly as possible. To prevent obstruction of $CO_2$ in the line, the pipe should be bent around its corners gradually, instead of making sudden turns through nipples and elbows.

While automatic valves which release the gas when a dangerous temperature is reached are available, manual control is perfectly satisfactory in small boats. The release mechanism should be located right with the engine controls. The entire installation can be made up very inexpensively using war surplus $CO_2$ equipment and brass pipe. A ten-pound extinguisher is adequate for the average small cruiser; a twenty-five-pound tank of gas will flood the danger area in a large auxiliary. You can bleed $CO_2$ gas from a small line into the galley, so that when there is fire or explosion danger, you extinguish the galley-stove fire at the same time that you put out the engine-room blaze.

**Propellers**

The shape, pitch and diameter of a propeller are of extreme importance to your boat. At any speeds ordinarily associated with pleasure craft, the propeller generates a jet of water which drives the boat forward by the law of action and reaction. This states, in propeller terms, that the thrust which forces the boat through the water is the product of the mass of the water driven by the propeller, multiplied by the acceleration of that water. It is only on the extremely high-speed hydroplanes that the propeller screws its way through the water as though it were in a solid medium

Now, when the propeller tears up the water without thrusting it back from the working surface of the blades, it is said to "cavitate." This vibrating, turbulent state is not only wasteful of power, but it also damages the propeller. What the propeller wants to do is deliver a jet or slipstream. This sometimes means that for the propeller to work without cavitating, we must decrease the pitch or angle of attack of the blades. The sailboat man dislikes this, because a flat blade has greater drag under sail, so he will be forced to reduce the blade area as well as the pitch. In general, it is safe to deviate from the propeller recommended for your engine by an inch or two of pitch, but never do so if this reduces the maximum r.p.m. that your engine is capable of. You will find that under adverse conditions, particularly in heavy seas, your engine can only develop its torque, or driving power, if it is allowed to turn over sufficiently fast.



If you consider the area of the propeller compared with the area of the underwater portion of your boat, you will understand that a nick or dent in the blades is equivalent to a huge area of hull damage in its resistance to the water. You can see, too, that proper maintenance of the propeller is vital to the boat's good performance. A foul propeller, for example, is almost useless, and completely dangerous when you require forward and reverse control in maneuvering the boat. If you leave your boat in the water in areas where fouling can take place, you must either scrub the propeller regularly or keep it well painted with antifouling.

*Making the Boat Self-steering by Propeller Angle*

Motorboats and auxiliaries with single engines can be made self-steering if the thrust from the propeller is deflected to counteract torque. You see, the bottom blade of a propeller works in water several inches deeper than the upper blade. Small as this distance is, you must remember that sea water weighs sixty-four pounds per cubic foot. The difference in pressure over those few inches of depth is enough so that the bottom blade kicks the stern of the boat away from it with greater force than does the top blade. This torque can be compensated for with very minor deflection of the propeller's stream. Large-diameter slow-speed propellers exert a greater kick across the wake of the boat than the small-diameter high-speed ones. For this reason it would be difficult to formulate an equation telling you the exact amount to offset your engine. Experience provides us with some good proportions, however, and the illustrations in the chapter on "Construction," show typical installations in several boats where offsetting has proven to be satisfactory. See Plates 1-5, 8-5, 9-5, 10-5.

You must be very careful to reason out whether you wish to offset to the left or to the right. Think of it this way: when you stand at the stern of the boat facing the propeller's working surface, if the bottom blade moves from right to left it will kick the stern of the boat in the opposite direction, that is, from left to right. Now, to counteract the motion of the stern from left to right, we want to deflect the stream from the propeller off to the right side. If the bottom blade of the propeller moves from left to right, we shall have to deflect the stream exactly opposite to the first case; we want to deflect it this time to the left.

Notice that our reasoning deals only with the bottom blade. It is important to remember this point because propeller designation, specified by the engine manufacturers, indicates the direction of a propeller by the motion of the upper blade. Don't forget, as we noted in the beginning, that the upper blade does not exert as much force as the lower and therefore does not concern us in our reasoning for overcoming torque.

*Contra-fairing*

Contra-fairing is a method of feathering the propeller aperture so that it best delivers its water to the propeller blade on a centerline installation, and best lets that water pass the rudder as the blades thrust it aft. In the drawings showing the construction details of a modern yawl, Plate 11-5 (diagrams 1 and 1A) shows contra-fairing. Look, also, at the aperture for the fast Lobersterman launch, Plate 9-5. There you will see contra-fairing indicated on the lower path of the deadwood of the port side of the boat. Contra-fairing on the starboard side will be on the upper half of the deadwood only. Now, this contra-fairing is a paring away of the deadwood on the side opposite each advancing blade of the propeller. You can see from looking at the diagrams in Chapter 5 that with a right-handed propeller, that is, one on which the upper blade is moving from left to right, we pare away the right-hand side of the deadwood above the propeller shaft and the left-hand side of the deadwood below it. This enables the advancing edge of the propeller to bite into water which has been as little disturbed by the motion of the boat as possible. Water thrust back from the propeller needs contra-fairing on the rudder in such a manner that the contra-faired faces above and below the propeller shaft line are parallel to their opposite faces on the deadwood.

The practice of contra-fairing has existed for several decades among the most skillful designers. Where boats with conventional apertures have been contra-faired, they have shown an increase in forward thrust for a given r.p.m. with a decrease in fuel consumption. In some cases this advantage has amounted to fifteen per cent or more. If there is any secret to proper contra-fairing, it is to make the pared-away areas as gradual and as extensive as possible. A half-hearted approach to contra-fairing will yield no advantage at all. This technique is also an approach to eliminating backlash in propeller installations on boats with thick deadwoods and thick rudders.

On auxiliary sailboats with contra-fairing, to reduce drag under sail, you must arrest the propeller a little "early" of its up and down position behind the deadwood. Contra-fairing decreases the drag under sail as well as it increases the efficiency under power so long as you observe this one precaution.

CHAPTER 5

# Fundamentals of Construction

CONSTRUCTION IS AN AREA of boating closely allied with design. Often, in order to achieve some style or effect, designers create shapes which require complicated building techniques. These are always undesirable and are costly as well. Their undesirability lies in the very definition of design, which is the attempt at the simplest possible solution to a given problem. You see, if you were not making an attempt to solve the problem in the simplest way possible, there would be no need to design at all. You could arrive at your solution by hit or miss methods that might be costly and take a long time to develop.

You can see from this that the only way we can judge whether a design is good or bad is to look at the number of steps involved before the problem was solved. If we can discover a way to eliminate any one of these steps we know that the design is not the simplest solution. Of course, because technology, time, or money may affect the means by which we arrive at the design, very few designs can be considered perfect. But if a boat has been built in a complicated manner, we can be sure that she is not well thought out. It will be up to us, in maintaining and repairing such a boat, to see our own best means of doing the work rather than imitating the existing construction. In this chapter, then, we will discuss boatbuilding at its most fundamental level, so that, by applying basic principles, we can build, repair, or replace any part of our boat.

The classic and still most common method of boatbuilding is first to assemble a keel and skeleton upon which planks are attached to form the hull and deck. In Chapter 1 we discussed the methods of planking this

framework and we continued through the evolution of construction with reference to modern materials and the uses to which they have been put. Now we must retrace our steps, looking at each phase of these constructions as through a magnifying glass.

**Keel**

Generally thought of as the backbone of the boat, and therefore often built in massive proportions, the keel is actually a very simple member. It, like stem, horn timber, transom and frames, serves mostly as a fixture of attachment. Most of the weight in a boat is located in the general midship area and, because of this, plus the downward force exerted by the mast of a sailboat and the tensile forces of the rigging, the keel itself becomes principally a tensile member because it is held at its fore and aft ends where no load is placed upon it. The keel, however, gets considerable assistance in its work. You see, the keel is attached first to the garboards, which are the bottommost planks, and these in turn are attached to the stem and sternpost, so that they share the keel's work and help to keep it from deflecting. Then, on top of the keel, the floors, or floor timbers, are fastened. These floors carry the frames and, because all this again ties to the planking, the hull shares the keel's load continuously. See Plate 1-5.

Now, if you have formed a clear picture of the interrelationship of these several structures, you will see that it is possible to build a perfectly satisfactory, top quality boat without any keel at all, and some of our best designers have done this quite often. However, boats which are designed to include a keel utilize it as a fundamental member, so we must discuss its anatomy and function somewhat further.

**Propeller-shaft Holes**

In power boats that use inboard engines, the hole in the keel through which the propeller shaft must pass is often an area of cracking, checking, or splitting. This damage can usually be traced to vibration, although it sometimes results from the builder having inserted a strong metal tube to protect the wood from worms, and the wood, having swelled against this tube, fractures itself. Once the wood has split, it has relieved itself, but you must determine which of the suspected causes was responsible before you attempt repairs. If vibration was the damaging agent, the propeller shaft must be straightened and realigned. Then, when the wood is thoroughly dried, apply an adhesive to the split, either epoxy resin reinforced by chopped-glass "dust," Borden's "Elmer's" waterproof glue, or Weldwood waterproof glue. Be sure to remove the excess adhesive from the shaft aperture before the material sets. Smooth off the outer surface and overlay a patch of fiberglass fabric and epoxy resin.

If the keel split from swelling against a tube, do not attempt to force



the crack together. Instead, make a putty of epoxy resin and chopped-glass fibers and work it into the open area with a large-bladed putty knife. Again, it is good practice to apply a patch of glass fabric over the exterior when the filler has cured. It is best, to assure proper curing of the epoxy resin, to apply a heat lamp to the area for several hours after the resin has been applied. This can be one or more infrared bulbs brought close to the work and aimed squarely at it. See the section in this chapter on fiberglass techniques.

**Stem**

In old boats, and those in which the rigging has been carried too tightly, it is not unusual for the stem and keel to work apart. When this occurs it is generally through the agency of the apron, that knee-like structure that bridges the angle between stem and keel. As the boat works in a seaway, the deck, hull, and stringers yield a little bit and the apron becomes a fulcrum against which the rigging pulls the stem head. It takes some observation to determine the exact cause of the opening. First check the hood ends of the planking, that is, the ends which attach to the rabbet of the stem. If they are sound, and the fastenings are secure and free from electrolysis, check the stem itself for rot. Now examine the decking in the general forward area of the boat. The deck helps the stem and planking retain their relative strength and positions. If it is rotted, or the fastenings are gone, the stem is free to move aft as the boat works. Finally, check the apron. It often is the main connector between the keel and the stem. If it is cracked or rotted, or its fastenings are eaten away, the stem and keel may be quite isolated from one another.

A deteriorated apron can be pried out of the boat after first carefully cutting it away from stem, keel, and planking fastenings. These fastenings are then backed out, or filed flush, and a new apron tailored to fill the cavity. It is extremely important that any wood or metal which will be covered by your repair work be in perfect condition. Rotted, spongy wood, moist-corroded metals, all must be cleaned out or the disease condition will continue. While the use of preservatives, such as Cuprinol and Woodlife, prevent and arrest rot, you must still scrape away the decay before you rebuild. One excellent approach to seating a new apron is to lay it in place against a thick "washer" of polyester resin impregnated fiberglass mat. This will fill up areas which might otherwise collect moisture and begin to break down. The same treatment we have just described for stem and apron repairs applies as well to sternposts, horn timbers, and floors.

**Floors**

Floors, the sturdy timbers which lie across the keel and attach to the frames, also carry the bolts for ballast keels in sailboats. They are subject to

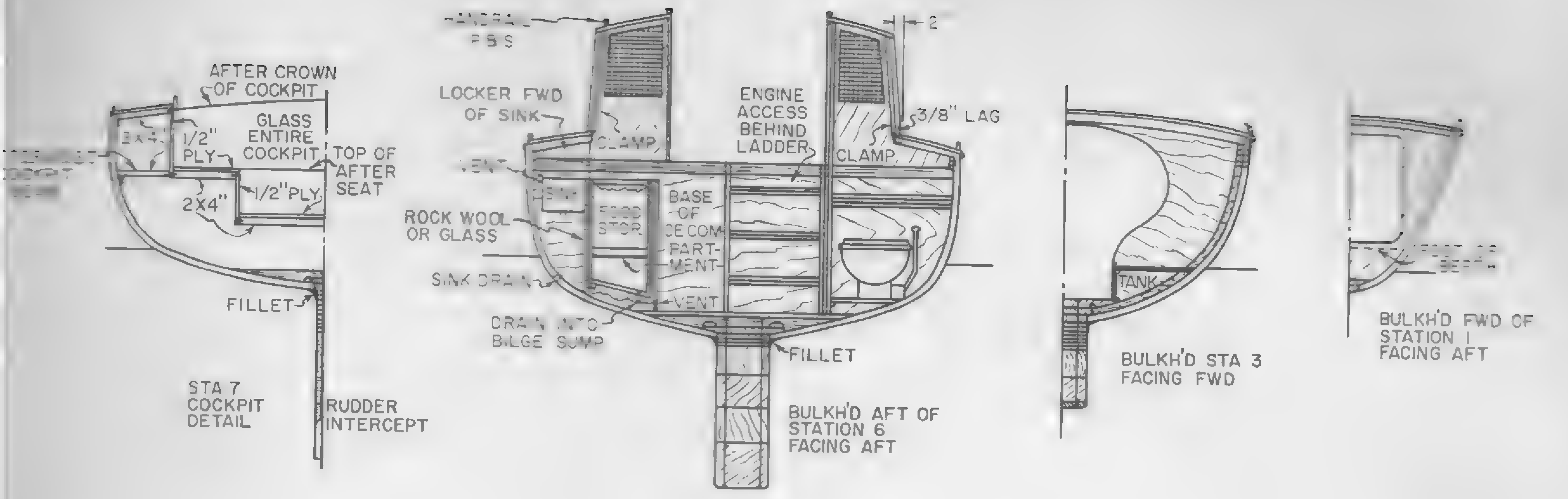
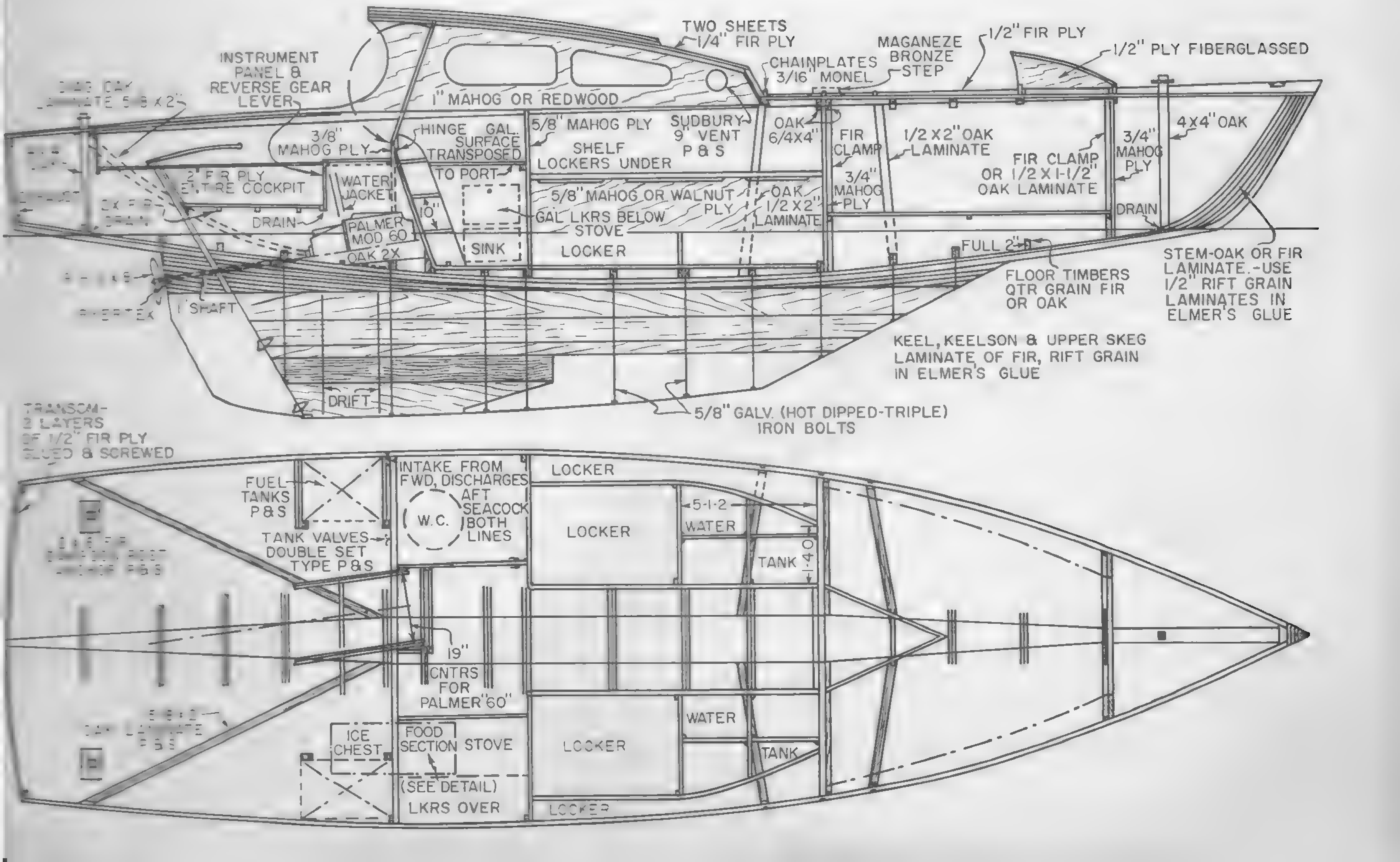



Plate 1-5. Plans for a 29′ overall light-displacement auxiliary sloop. Construction plan shows offset engine installation with centerline propeller to counteract torque and make self-steering. Note simple frame and bulkhead arrangement for strip-planked, fiberglass-covered hull; there are no stringers or clamps or shelves in the construction. Deck beams set into individual sockets of plywood along sheer of hull. Note icebox construction in midship sectional drawing. Note also raked after bulkhead to give sitting comfort on deck; swing-down panels to ventilate in hot climate. Note windscoop type of forward hatch.



rot from fresh water in the bilges, generally at the limbers, which are the holes through which bilge water is free to pass. The proper repair to a rotted floor timber is replacement. Where a floor has split from pressure against the keel bolts, the repair is similar to that of the keel which split against the propeller-shaft tube. First you must allow the wood to dry thoroughly, and in this case the glues will not be adequate for the job. You must use the epoxy-resin putty, trowelling it thoroughly into the split.

In some boats you will find that the frames set into the keel in notches, carefully mortised for each frame. Often, where this construction occurs, the ends of the frames and keel both have rotted. This is a bad situation and is the result of mistaken reasoning on the part of the designer or builder. They have assumed, you see, that the bottom ends of the frame carry a great load in a fore and aft direction. Of course, this is not the case and the principal function of the frame is to keep the planking in line so that the strakes remain in close relation to one another and the caulking can't fall out. Frames do very little else except lend some local strength to the boat but we have already seen how, in strip construction, a strong and watertight boat can be built with no frames at all. Nothing is gained from imbedding the frame ends in the keel except increased cost and greater risk from rot.

If the rot damage is not too great, dry the boat out carefully and literally soak mortised areas with wood preservative. Then build up auxiliary floor timbers wherever the rot has been extensive, transferring the load of the keel higher on the frames. If the damage is severe, you may have to preserve the entire area with a rot arrestor, after stripping out the old floor timbers. Next, lay a new keel on top of the old one and hold it in place by new keel bolts, passing through holes already in the old keel, up through new floor timbers. These floor timbers will then be fastened to the old frames, but at a new, higher point. The fastenings from the garboard, into the old keel, may be left alone, but you may need a new, second set for the new keel. It is important, in severe repair work of this nature, that the new keel fits accurately to the old. For that reason, it's good practice to set it in a gasketing compound, such as asphaltum. Thoroughly saturate all surfaces with wood preservative, particularly the ends of the grain.

**Engine Beds**

Engine beds are the structures which raise the engine from the bottom of the boat, keep it and the propeller shaft in proper line with the bearings, and hold the engine in place against movement from torque and from being thrown by the rolling of the boat in heavy weather.

Inboard-powered motorboats sometimes develop engine-bed troubles,

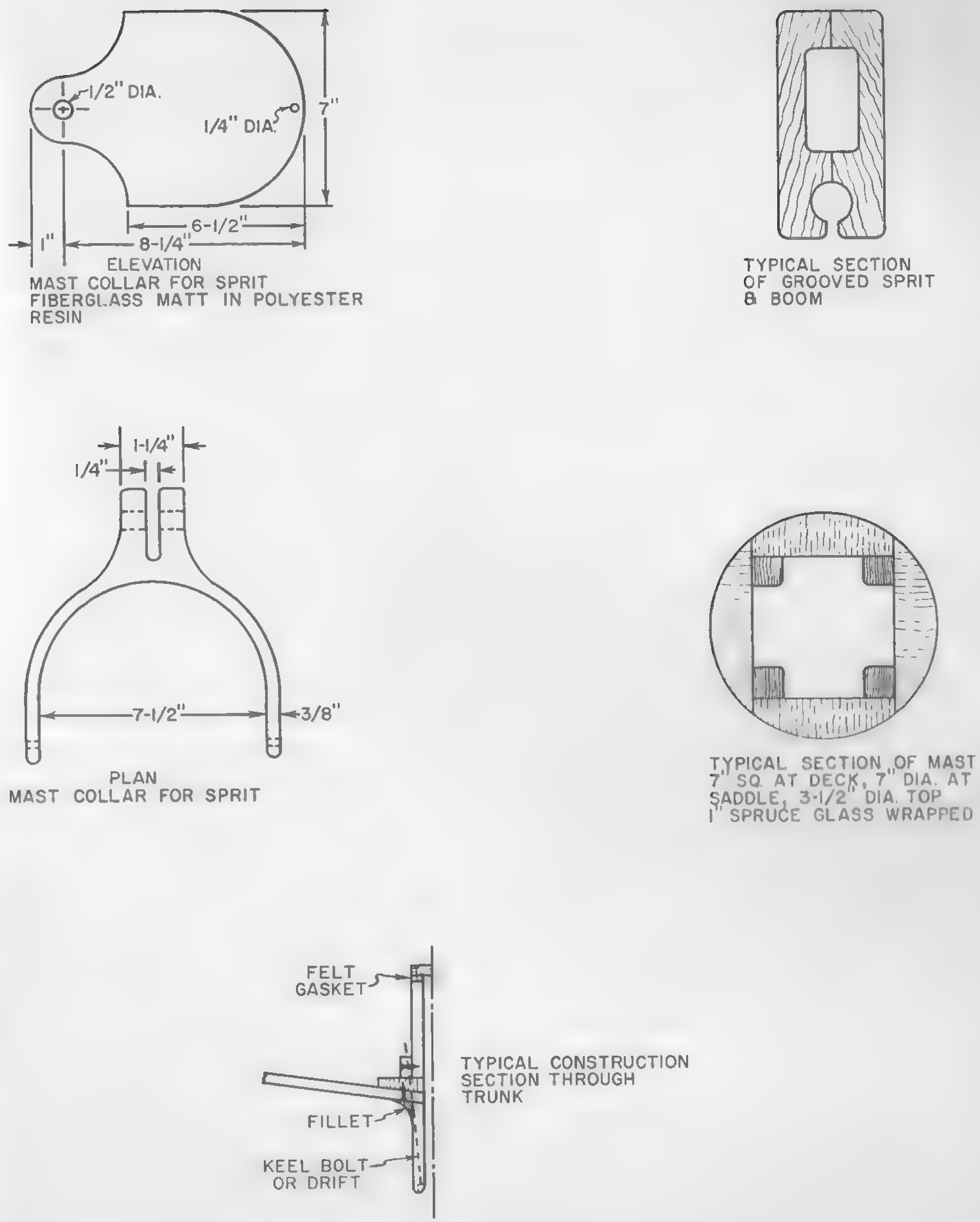



Plate 2-5. This detail sheet shows the mast saddle for the sprit, in this case, the gunter, for a 20′ catboat. Also shown are typical sections for round or square spars. The grain lines in the drawing indicate rift grain spruce. A typical section is also shown for a wood centerboard trunk. The trunks on these boats are fiberglass lined.

and these are almost always the result of vibration. Either the entire bed begins to loosen in the boat, or the hold down bolts of the engine try to split the bed.

The first step is to detect the cause of the vibration. It may be shaft alignment, flywheel unbalance (detected by running the engine in neutral), poor timing adjustment, or an unbalanced propeller. In any case, correct this before you condemn the bed itself.

A bed which is not rotted, but has worked loose from the hull can usually be fixed by setting in screws from outside the planking, right through the hull and into the bed. To locate the line of the bed, drill a pinsize hole at the fore and aft end of each bed timber, or alongside the bed if you can't work a drill in at the ends. You can repair these holes later with glue. If your line lies to one side of the bed, be sure to measure accurately to the center of each bed log. Use naval bronze lag screws if you have thick planking and can countersink the heads. However, large, flat-head naval bronze or phosphor bronze wood screws are perfectly satisfactory, and in thin planking (less than one inch thick) are necessary. Use many screws, but you must drill for each one first, or you are certain to split the bed. Your pilot drill should be the size of the screw inside the threads. Always lubricate the screws before you drive them. Rubbing the threads on a cake of beeswax is a good method.

One last trick, in setting a line of screws into a single piece of wood, is to stagger them in a slight zig-zag pattern, so that the holes of adjacent screws are not in line with one another. This gives the grain of the wood a chance to distribute its loading without danger of splitting.

Occasionally an engine bed will split longitudinally, either from vibration or from careless installation of the hold down bolts. When this happens, you must first check the crack to see that the wood is sound. If it isn't, you will have to splice in a new piece. But where there is no damage from rot, pull the engine-bolt, work glue (Weldwood is the best, here) into the crack, and set a snug-fitting dowel into the hole, after coating it with glue. Clamp the cracked area together until the glue has set, then redrill, and this time be certain that there is proper spacing for the lag screw or hanger bolt. As before, use a drill having a diameter the same as the screw diameter inside the threads.

If you have to alter an engine bed to accommodate a new engine, it is usually simple to glue and screw side pieces directly onto the existing bed. Where you are widening the bed to accommodate a larger engine than before, it is often possible to cut the old bed down enough to clear the increased width of the engine's underbody, then build up on the outside of the existing material to take the engine-mounting lugs. Always provide generous limber holes around the bed, so oil, fuel, and water cannot lodge there.



**Centerboard Trunks**

The centerboard trunk, sometimes called the centerboard well, is the housing inside the boat which, because of its watertight construction, allows the centerboard to be raised flush with the bottom of the hull. See Plates 2-5, 3-5, 4-5, 5-5, 6-5.

There are an infinite number of ways to build centerboard trunks, and if you have an old boat you should be prepared to find some surprising varieties of construction. Often what appears to be a simple assembly will contain a dense network of drift rods (vertical rods driven into the wood), so it is usually wise to try repairs before you try replacement. Unless you have rot, which rarely occurs in centerboard trunks in salt water, but is rather common in fresh-water boats, your probable centerboard trunk problems are worm damage, accident damage (where the board breaks or strains the entire trunk) and simple leaking. This last is best attended to before the boat is launched in the spring, for then a touch of elastic seam filler will generally put things right. However, in a trunk which is of batten or tongue and groove construction, making it impossible to caulk, it is best to scrape down to the bare wood, prepare the surface for fiberglassing, and then cover with at least two coats of glass and polyester resin, as described in the fiberglass part of this chapter. You won't have so simple a task if worms or rot are present, because in these cases you are really obliged to pull out the trunk and build a new one.

Where room inside the boat permits, the easiest way to remove an old centerboard trunk is with a metal cutting blade and power saw. If you can manage this, cut the trunk off flush with the keel. Any attempt to salvage or leave part of the old trunk will involve more work, in small boats, than it is worth. At the fore and aft ends of the centerboard slot you may find some end-grain vertical posts remaining from the ends of the trunk itself. These, too, should be removed so that you are now in contact with the keel itself.

Examine the keel to see that it is free of worms and rot. If there has been keel damage, you will just have to cut away in all directions until you hit sound material. You see, both worms and rot which are already in the wood have already done their damage and, although you can prevent further trouble, your chain of repair will be limited to the strength of this weakest link.

If you do have to enlarge the centerboard slot to any great extent to clear away destroyed material, cut back enough so that you can build back to the original opening with new wood or with fiberglass and resin. Be sure, when you fit this new wood into place, you can do so with a good glue joint. Make the side "fillers" for this type of repair reach to

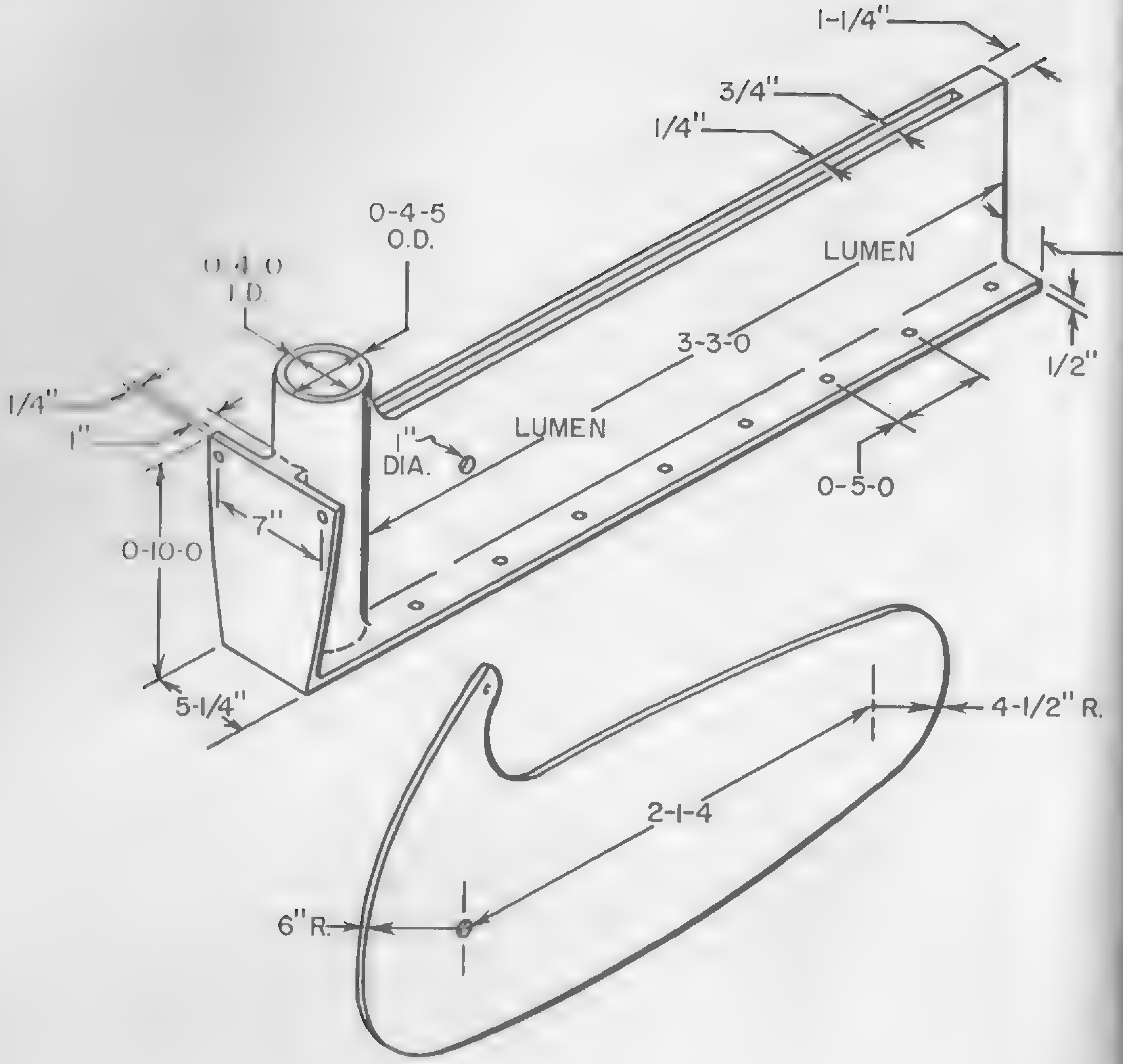



Plate 3-5. Design for a 14′ overall dinghy with cantilevered rig. This is a detail of the centerboard trunk-maststep molding and the centerboard itself.



the extreme fore and aft ends so that you can wedge them in place from above and below for their full length while the glue dries. The proper adhesives for this will be either "Elmer's," or Weldwood waterproof glue, or epoxy resin and fiberglass mat. The epoxy and mat are preferable here, but the others are satisfactory. Because the mat acts as a gasket to fill irregularities, you will have a good job without the accuracy that the other adhesives require.

Now, at the ends of the newly built slot, erect the vertical posts to carry the sides, or walls, of the trunk. These should be of a fairly strong wood, such as clear-grained fir, and they should be treated to protect them from new rot and worm attacks. Preservatives can be used after the posts are glued in place, or the posts can be first wrapped with fiberglass and resin, sanded smooth, and "glued" in place with epoxy resin. If you choose to cover them with glass, be sure you cap the lower ends as well as the sides and edges. To hold these posts in position, it is useful to make them a foot or so longer than they will be finished, then clamp some braces across the boat and tack them to the posts. If time and money permit, you should now line the slot in the keel, between your end posts, with fiberglass, working the glass up on the top of the keel into a flange, and then repeating this on the outside of the keel beneath the boat. A second-best technique is to creosote this area thoroughly. The one weakness to the creosote method is that abrasion from sand, pebbles, and barnacles will ultimately scratch up enough of the creosoted wood so that worms may again get in. The only way to keep them out is by proper attention to this area each time you haul the boat.

Your new trunk will be made of fiberglass-covered plywood and, in order to get a good surface, it's best first to cut the material to size, then glass it while it is flat on the shop floor. Use marine-grade plywood at least ½″ thick so that there is ample material to take fastenings. Glass cover it right out to the edges and let it set. Then mix a thick resin, using epoxy or polyester plus an additive such as aluminum silicate or chopped strand glass, so that you can set the sides of the trunk in a putty of resin along the keel and the posts. Wipe off any excess resin inside and outside the trunk. Use Anchorfast nails to clamp the trunk to the posts, drilling for the nails first, and backing the blows of your hammer with a counterweight. If the inside, upper surface of the keel is in good enough condition to accept glass and resin, you can flange the lower edge of the trunk directly to the keel with glass and resin. Use epoxy, here, and fiberglass tape. In boats under twenty-five feet, with suitable keel surfaces, four layers of tape should be satisfactory. Use six-inch-wide tape for the first two layers and four-inch for the second two. Where there are to be unusual loads on the trunk, such as in a racing boat with a heavy, ballasted centerboard, you will want to use a

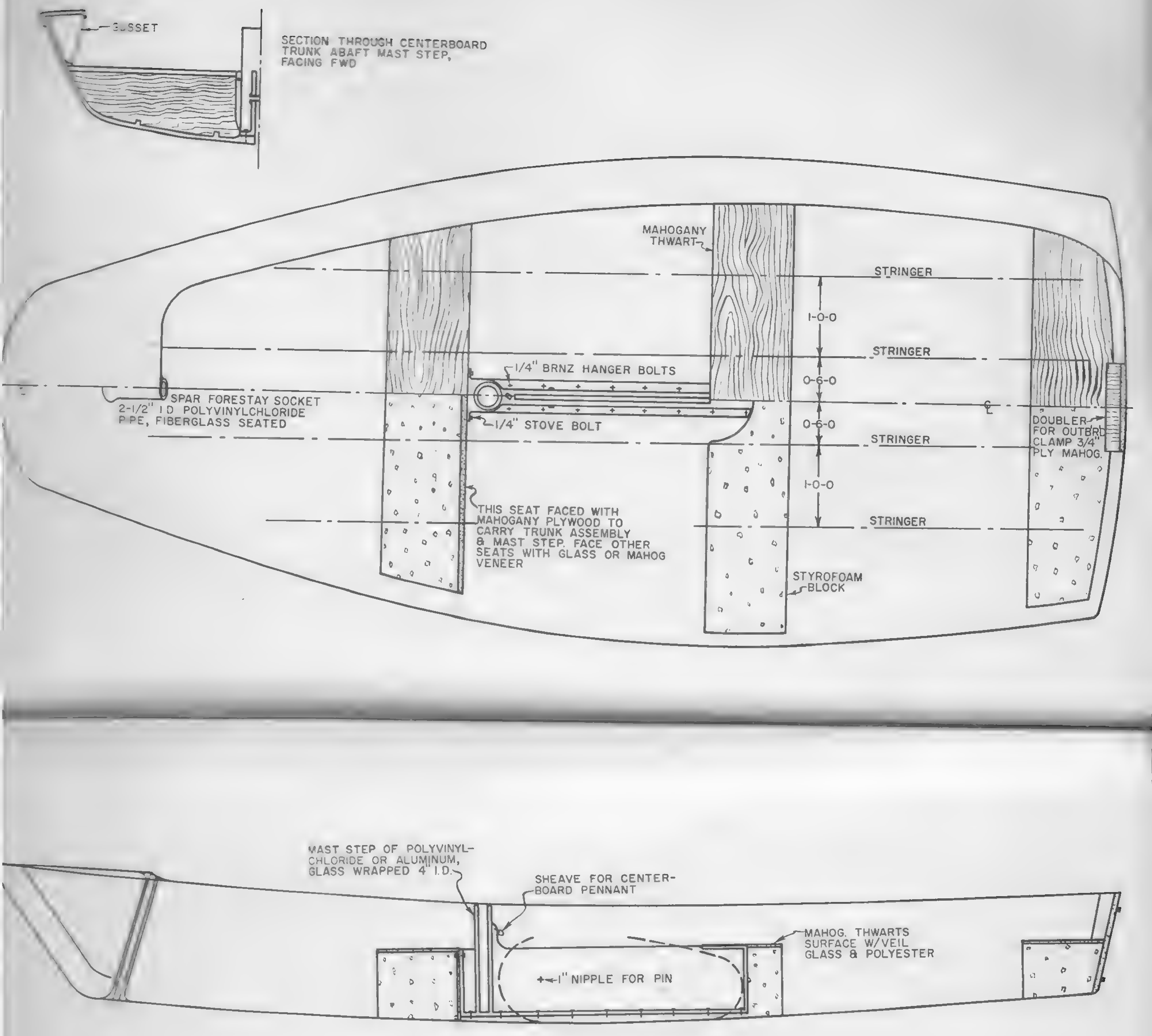



Plate 4-5. This page shows the construction plan of a 14′ overall dinghy with a cantilevered mast and spar forestay. The mainmast step and centerboard trunk are molded fiberglass and are a continuous lamination. The trunk in this boat is designed to be bolted in place or removed and the slot covered with a filler plate, depending upon the requirements of the owner.

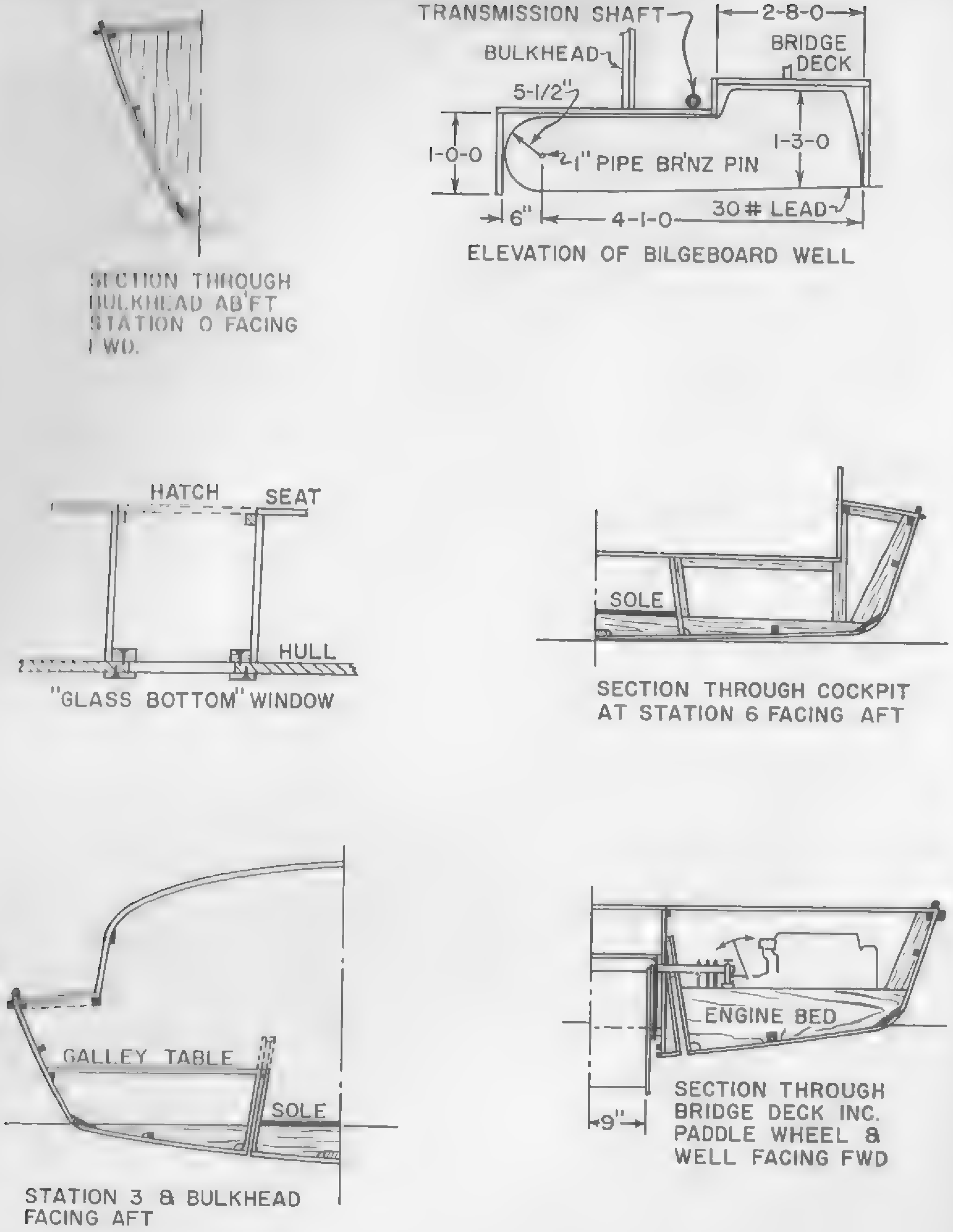



Plate 5-5. Design for a 23′ paddle-wheel-driven auxiliary with twin centerboards. Note twin centerboard installation in sections. Centerboard trunks also act as vertical walls of compartments, saving construction and cabin space. Note also detail sketch for glass-bottom window in boat. Section through cockpit at station 6 shows strong simple cockpit structure.



trunk log. This can be built of clear fir, glued and screwed to both the keel and the trunk. For a trunk with ½″ walls, a one-inch-square log is satisfactory.

Most small boats have no cap over the centerboard trunk, but if you prefer one, use a T section piece so that you can fasten it from the sides of the trunk walls rather than into the edges.

## Mast Steps

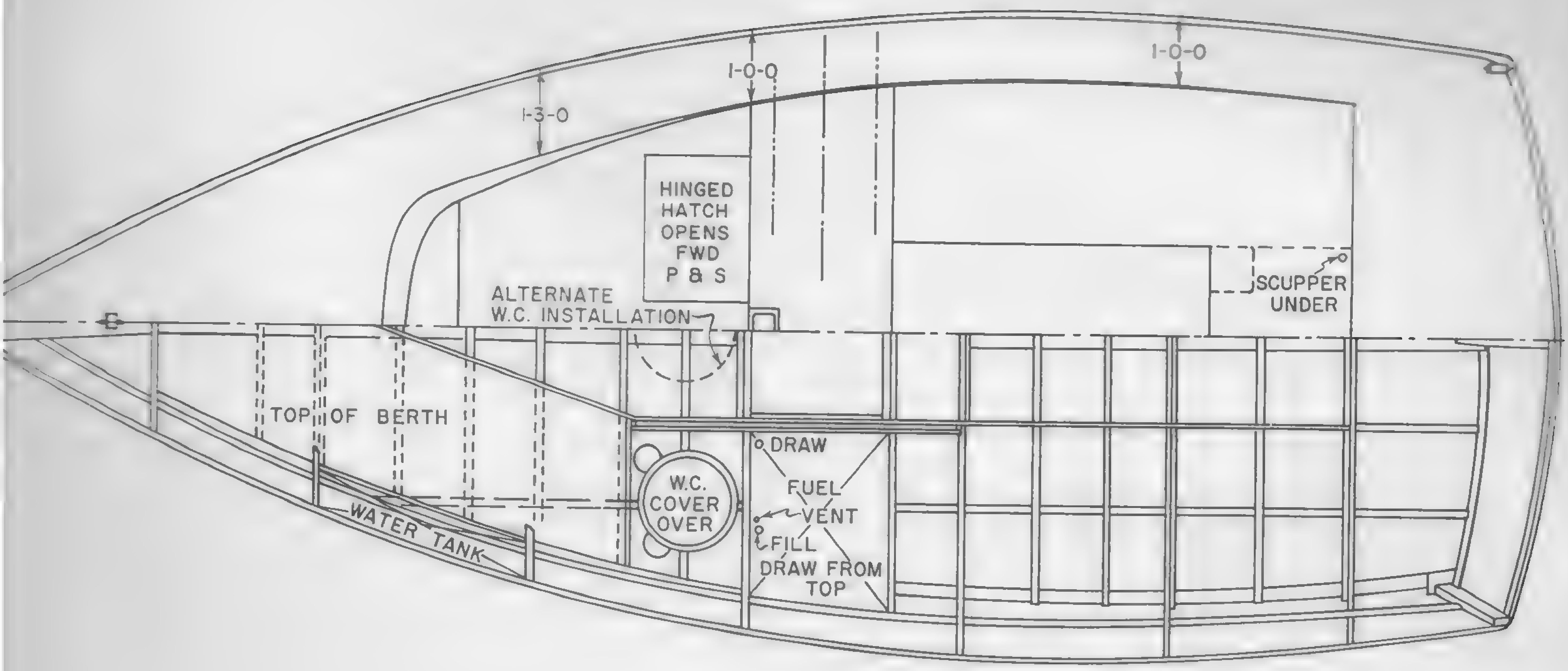
The mast step is that device into which the foot of the mast is seated. See Plates 3-5, 4-5, 7-5, 8-5. The step not only keeps the bottom of the mast from moving about when the spar is under a load, but helps distribute the downward force of the mast over a large area of the boat's skeleton. Although mast steps are usually strongly built, they get a tremendous amount of abuse. Fortunately, they are rather easy to repair or replace. Proper maintenance of the mast step is very simple: the step should be saturated with wood preservative every time the mast is out of the boat, and it should be kept clean and dry of bilge water and protected from rain leakage.

Mast steps are primarily compression members and, although they are subjected to varying amounts of side strain, this is usually rather slight. However, in wooden boats, the mast steps are usually of oak or fir and are very subject to rot. For this reason, the mast step is not only well soaked with preservative, but should also have a generous drain hole at its bottom. Fresh water, trickling past the coat of the spar, works its way into the wood, and quickly breaks it down. The legend that good luck follows a silver coin placed beneath the foot of the mast is probably connected with the fact that the silver coin raised the mast enough to let this water drain out of the hole.

If a step splits, it generally does so from swelling against the spar. This can be repaired by drilling through the step directly across in front of the socket and behind it, and drawing the pieces together with a carriage bolt through each hole. First, however, treat the crack with preservative.

If the step rots, it must be removed and replaced. Let the new step cover three floor timbers, if space permits, and slightly notch these timbers to receive it, so the step can't work left or right. If the mast will of necessity fall between two floors, the step need be no longer than the distance required to bridge both floors. In this case, however, carry the step right down to the keel between the floors and drain the step by a limber hole out to one side.

Use rift grain wood for the step and, if the strains will be great, run through carriage bolts in the same manner as suggested for mast-step repair.



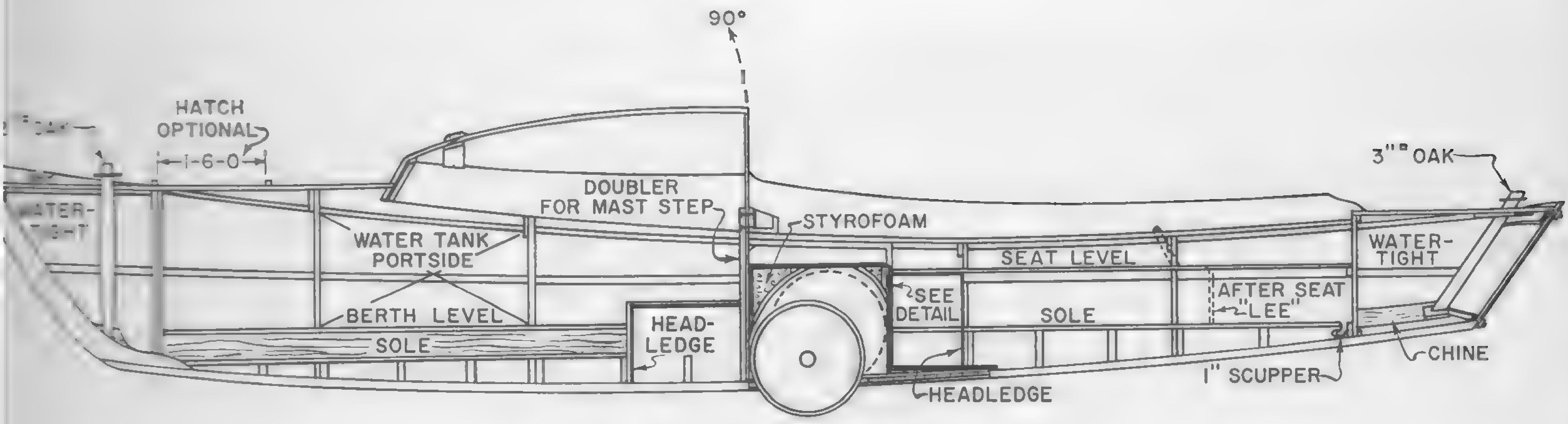




Plate 6-5. Paddle-wheel-driven auxiliary. Note twin centerboard construction to gain cabin space in shoal-draft boat. Centerboard-well faces are also used as walls of compartments. Note that paddle wheel is retractable into well which automatically closes. Note athwartship engine installation. Weight of engine is counterbalanced by weight of toilet, batteries, fuel and water tanks. Note entire cabin top can be swung vertically and an awning stretched from it to mast and back over cockpit.

### Frames

Frames, sometimes referred to as ribs, are used to hold the planks in their proper, boat-shape curves, and also to anchor the planks of caulked boats to keep them from separating as the boat tries to twist under strain. In metal and laminated or monococque boats, the frames add local strength, primarily, and only occasionally serve as forming members. Because of this, you can see that a damaged frame constitutes a serious injury to a caulked-seam vessel and must be attended to as quickly as possible.

In a fiberglass, strip-planked, or molded or welded boat, frame damage is usually a long-range danger, not likely to show itself until extreme loads are put upon the boat.

Fortunately, in all cases frame repair tends to be simple. Whether damaged by rot, split from swelling, or cracked from accident, the basic repair is made by building a "sister frame" alongside the injury. In a wooden boat with fairly tight curves, it is generally easiest to laminate the sister frame of several thin layers of wood such as slash grain oak, fir, or mahogany. Of these woods, fir is especially desirable because it is readily procurable in any size, takes glue extremely well, and is a nice blend of strength per unit weight.

Clean the area around the damaged frame and prepare the surface of the old frame and the adjacent planking to accept a glue bond. "Elmer's" or Weldwood waterproof glue are recommended here. Glue one layer of repair material in place at a time, securing it to the hull with Anchor-fast nails. If you want to repair a frame on a caulked boat, apply glue only against the old frame, not against planking, for this must be free to shrink and swell. You can attach the planking to the sister frame from outside the hull, after the glue has set. Your new frame should be the same dimensions as the old one, but carry it at least eight inches both sides of the damaged area for a frame about ⅞" wide. When it is set, soak the ends with wood preservative.

Metal frames in boats of wood, plastic, or metal, which have broken down from oxidation or electrolysis, can be wirebrushed clean, painted with an insulator, such as Rustoleum, and left adjacent to the new frame, which also should be insulated. However, if the hull itself has been attacked, there is little you can do except to back the damaged area with new sheet metal, set in epoxy resin and riveted in place. Unless you arrest the circumstances which caused the attack, it will soon recur.

### Stringers, Clamp, and Shelf

These are the fore and aft members, or longitudinals, running the length of the boat inboard of the frames. Because the framing separates these longitudinals from the planking, and because both the planks and these longitudinals are kept in fixed relations to one another, they form local "sandwiches," very much like the construction principle of corrugated paper and very strong. These members rarely crack, but they sometimes rot, particularly close up under old, leaky decks. While a split longitudinal can be repaired with a sister piece, just as we make repairs to frames, a rotten one may have to be removed entirely. This is usually tedious because these long parts pass through bulkheads, behind closets and other inaccessible places. However, if you saw the old piece into simply handled units as you take it out, and laminate in the new member as we did the sister frames, you will find it is a less frightening task.

These units are satisfactorily made from fir, pine, mahogany, elm, or oak, although oak is always dangerous to use if it is not well seasoned and left ventilated. When removing old clamps or shelves, be sure to check the deck beams and frames against which they've been fastened. The rot may have come from these beams or spread to them.



### Deck Beams

Deck beams are probably more subject to rot conditions than any other part of an old boat. You see, in a boat with planked decks, or decks with cracked fabric coverings, rain water works its way into the beam tops and ends and never gets sufficient ventilation to dry. Then, because the ends of the beams contact the sheer strake, or uppermost plank of the hull, and the beam tops are against the covering board, which is the most outboard plank of the decking, these parts tend to pick up the rot. Next, the rot attacks the clamp and shelf, which the beams attach to at their outboard ends. All together, you can get an extensive amount of decay from a leaky deck and there is no short cut to repair.

If the beams have rotted in just one or two spots, you can chisel out the damaged ones and build in new, as we did with the frames. But if many beams are involved, you must pull off the deck and replace the beams. This is a major operation and ought not be attempted by the amateur if possible, because the deck controls much of the shape of the entire boat. To keep the several compounds of the deck curve fair requires accurate carpentry. If you insist on doing the job yourself, make up several key beams before you begin tearing out old structure. You can laminate these beams just like sister frames, but don't attach them permanently to anything except the clamp and shelf. Be sure, too, that the ends of these key beams fasten adjacent to a frame head on each side. This is the location where they can least twist the clamp and shelf out of line.

Having secured these beams, make another set to go intermediate to them, always dividing up the spacing into approximately equal units.

When you have located beams in about six divisions, or modules, of the boat, it is safe to start tearing off old decking. But be sure that the boat is securely shored up on land, and that the bow and stern are choked against sagging, which they may do to some extent when the planking of the deck is lifted off. Now replace the remaining beams.

Make your new deck of marine grade plywood, ¼″ for a twenty-foot boat, ½″ for a thirty footer, ⅝″ for a forty footer. Plane the sheer to fit the bent plywood accurately and secure the ply to the sheer strake by glue and Anchorfast nails in drilled holes. A coat of fiberglass fabric set in polyester resin makes a superior deck and you can put a little nonskid paint-additive in the final coat of resin. Before locating a scupper rail on your new deck, pencil lines several inches long denoting the nail heads through the sheer strake, so you won't drill false holes for the fastenings. It is best to set the scupper rail in a bedding compound of elastic nature, such as Bedlast, by Kuhls, or Dolphinite. Hatch coaming can be wood stripping, set in a bed of polyester resin, tacked for clamping until dry in place, then covered with fiberglass tape and resin. Don't be afraid to make these coamings high. Their purpose is to stop water, and one inch is not too great a rise.

**Cabin Sides**

Where the sides of a trunk cabin have been destroyed or rotted away, the same heroic measures used on old centerboard trunks may have to be employed. In old boats, the inboard ends of the deck beams usually fit against a fore and aft member called a "carlin." This carlin is a piece of wood which bridges the distance between the bulkheads, which support it, and it, in turn, carries the sides of the cabin.

In more modern boats, the sides of the cabin trunk are either plywood or strong arrangements of natural wood and they act directly as bridges over bulkheads. In such cases, the cabin also carries the load of the deck immediately adjacent to it. You must therefore be sure you have accurately patterned the original curve before you remove the side, because the deck will sag until the support is brought back, making it difficult for you to get it fair. The simplest way to reproduce the curve is by making a template on roofing paper from the original cabin side while it is still in place. If its condition is so bad that the deck has already begun to drop, try to obtain a set of the boat's plans from the architect or builder. In the absence of these, you will have to work by eye.

The illustrations (Plates 7-5, 9-5) show the two basic methods of cabin-deck attachment in wooden boats. The newer method, where the plywood deck extends under the edge of the cabin side, is the better because it is extremely strong and simple and offers the least chance of rain water working into the joint.



**Cabin Tops**

Somewhat different from the deck, which has to help retain the shape of the boat, as well as perform its normal functions, the cabin top has little to do except tie the sides of the cabin itself together and support the weight of the crew. Therefore, it's practical to build this structure with no beams of any sort in boats under about forty feet overall. The key to this construction is called "prestressing," which is nothing more than forming a rigid, fixed curve in the materials from which the top will be built. Such a curve will remain in the top even if it is removed from the boat, much as the shape remains in a piece of molded plastic.

The technique involves shaping the curve into the fore and aft bulkheads which the cabin top will bridge, then beveling the sides of the cabin trunk so they afford an accurate contact with the curved plywood. See Plates 1-5, 8-5. You will want at least three inches of crown in a six-foot cross section, and it may be necessary to make up a temporary intermediate beam from scrap lumber if you have to join several pieces of plywood. Use ¼″ ply of exterior quality. It need only be perfect on one side, since you are going to sandwich two of these pieces on top of one another, bad sides inward.

Spring the first piece into shape, with its poor side up, and set it well in "Elmer's" or Weldwood waterproof glue, fastening it down with Anchorfast nails spaced at about three inch intervals around the cabin edges. Be sure not to secure it to the temporary beam, or form.

When this piece has set, coat its entire upper surface with the same variety of glue and spring the second layer into place. Tack this second layer down its centerline, fore and aft, using short Anchorfast nails or wood screws, then work outboard, using parallel fore and aft lines of fastenings, first on one side, then on the other. This will assure good glue bonding and will give you repeated opportunities to work out any irregular curves that try to develop.

You can build quite a compound curve by this method if you make several long, narrow, wedge-shaped cuts in both pieces of plywood before you begin. The way to determine the approximate areas to cut is to make a small paper mock-up of the shape you want, slicing the paper, and determining the angles of the wedges as you force it into contour. The irregularities in the plywood can be faired in after the glue has set by using Famowood plastic putty, which dries very hard without shrinking. The cabin top, like the deck, is best surfaced by fiberglass fabric and polyester resin, which should include a layer of antiskid material.

If you plan to cut hatchways into the cabin top, do so after the lamination has hardened. The hatch coamings will reinforce the plywood where it has been cut out and, in the case of a sliding hatch, the runners should

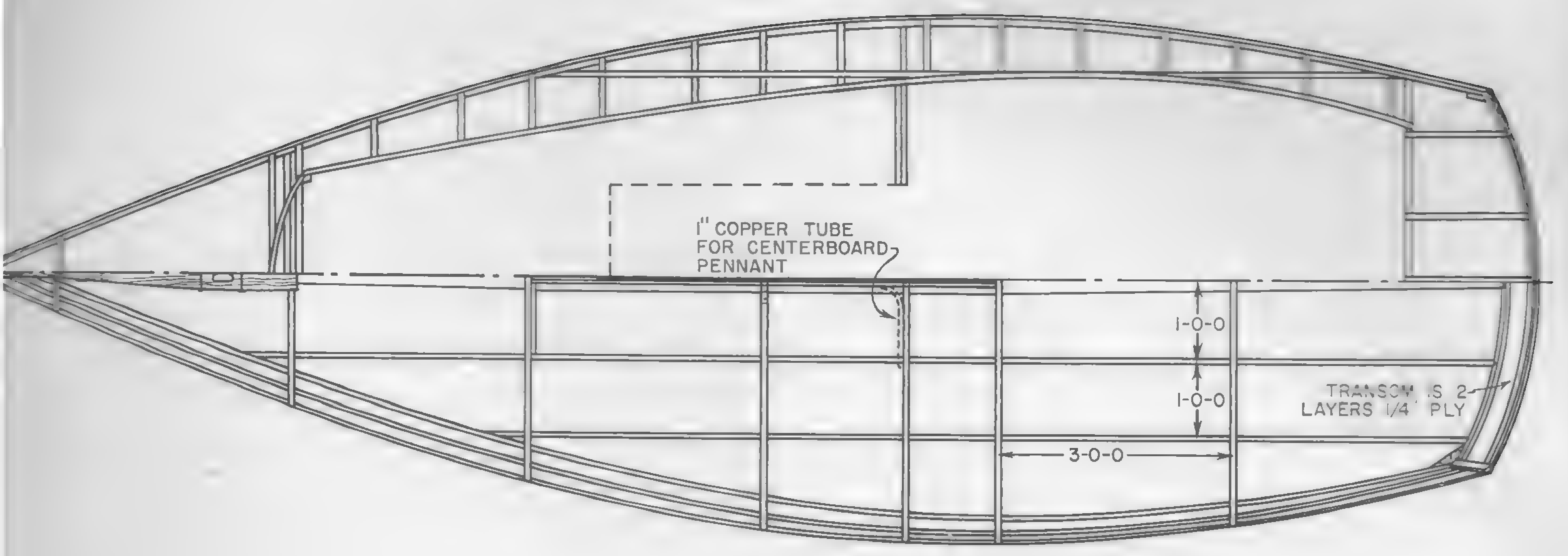
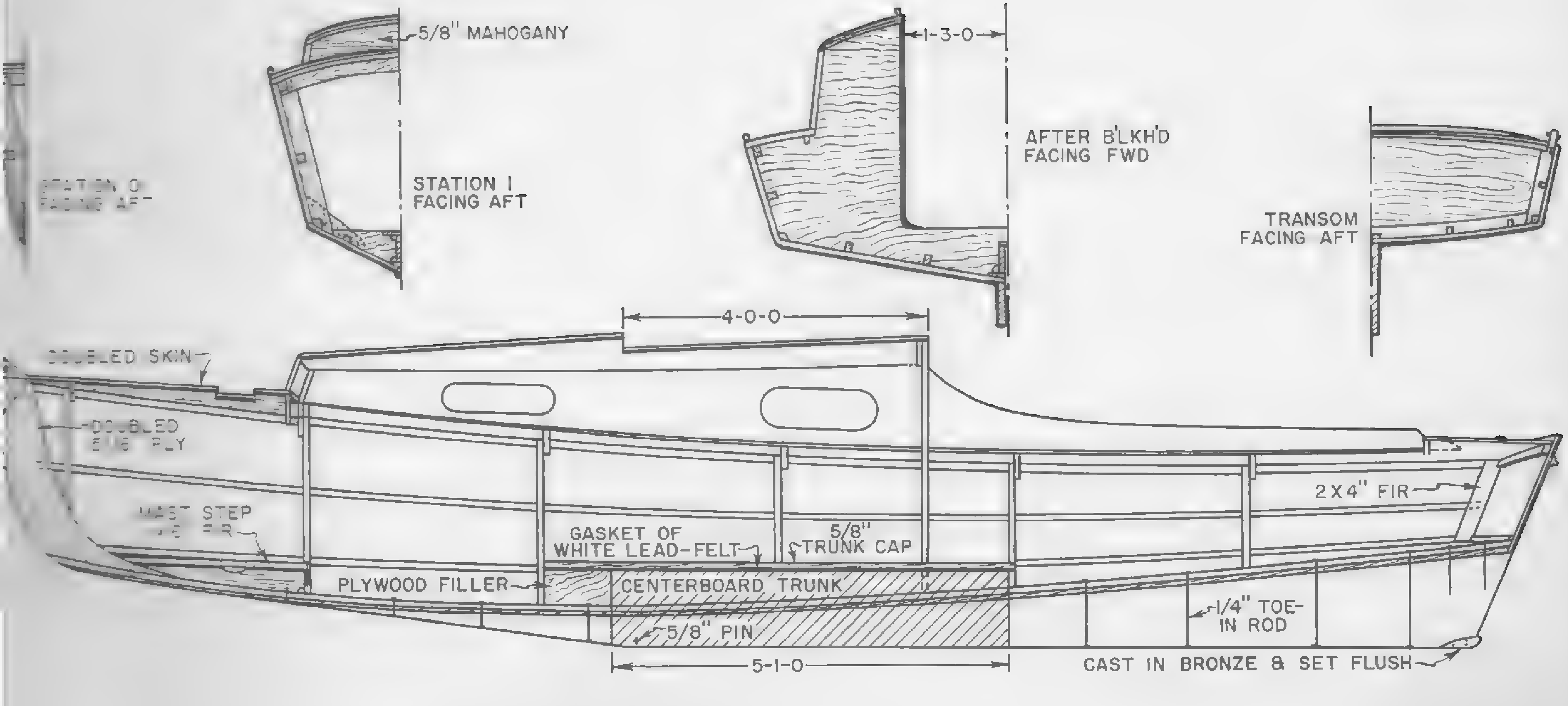



Plate 7-5. The Travel-Cat is a 20′ overall modern catboat designed to be built from either flat sheet fiberglass or plywood, fiberglass-covered. Here we see a particularly simple boat with good sailing lines. Because the cantilevered mast developed for this design puts great strains on the hull up forward, we notice a long, powerful maststep and a heavily reinforced deck. The sectional drawings show how the stringers are inletted into the frames and how the deck is attached.



be made strong enough to stiffen the hatch area. Set the runners in resin, against a gasket of resin-saturated fiberglass mat and draw them up tight with wood screws inserted from beneath the plywood, up into the runner wood. If you want to utilize the square you have cut out and make it into a hatch, you can slope the runners in toward one another at their top edges. This will make up the extra width you need to fit the hatch.

**Bulkheads**

While bulkheads are utilized as space-separators, they have a far more serious function: they act as panting members in the boat. When a boat under power smashes into a seaway, the first moment of impact tries to drive her bottom upward and the sides of the boat try to bow out. The bulkhead resists the deflection of the bottom of the hull by pressing down against it, distributing the force up its sides. It holds the skin of the topsides in against their tendency to bow, because of the planking fastenings it carries.

In a sailboat there is a different set of forces at work. The mast, driving down against its step, and the ballast keel, also pulling down, all try to straighten out the sectional curves of the boat, while the upward pull of the shrouds and stays increases this tendency. Here, the bulkhead holds the bottom up against the thrust and ties the sides of the boat down against the tension of the rigging. You can see from this that bulkheads should be very strong and well secured to the boat at close intervals. If the bulkheads are tied together by a big floor timber at the bottom and a cabin top or beam at the top, they also counteract wringing, which is the tendency of the boat to twist in response to the varying forces against different areas of the hull. The most important lesson to be deduced from this is that you must be very cautious in cutting or removing bulkheads in order to change the interior layout of a hull. Proper design and construction of bulkheads are vitally important; this means, too, that you must keep them in good repair.

Happily, bulkheads tend to be healthy structures. They can suffer from rot or accident, of course, but their usual failing is delamination, which occurs principally in plywood where the edges have not been perfectly sealed against moisture. Since it is generally only one side of the outer skin of ply which starts to break down, the repair is simple. You must soak the delaminating area with wood preservative. You may have to cut the damaged part away with a sharp chisel if you can't get the preservative to penetrate thoroughly. Then build up a sister frame tight against the bulkhead's edge, setting it in "Elmer's" or Weldwood waterproof glue, drawing each layer up tightly with closely spaced fastenings. Be sure, after the preservative has penetrated and dried, that you scrape the surfaces clean again before you glue, to ensure proper bonding.



**Berths and Shelving**

Berths and shelving have been grouped together because they are often continuous members and in many modern boats have very important structural duties. You can think of such structures as triangular girders, in which the vertical surface is tied to the hull to make a v, which is bridged across the top by the berth or counter top, and has terrific strength. For this reason it is always wise to allow generous lengths and widths of uncut surface when perforating these units for stowage hatches. In metal, fiberglass-reinforced plastic or uncaulked wood boats, it is good practice to utilize these surfaces for water tanks. The tanks are built up of fiberglass and polyester resin, after the wood has been thoroughly saturated with preservative. Use a thixotropic resin, such as Boat Armour, which contains a filler material that helps eliminate pinholes through the laminate. You must carefully fill all these tiny apertures with resin, then cure the tank completely by introducing a heat lamp.

The lid of the tank, which contains the filler pipe, can be made of fiberglass-covered plywood set in dense bedding or against a thick rubber gasket, held down with closely spaced wood screws. Don't forget to include a tube for venting the tank, or water won't run out and you might even explode the boat from pressure when you fill the tank by hose. Such an explosion can occur because the hose, forcing a small stream of water into a large tank, acts like a hydraulic jack and develops tremendous pressure. A vent will decrease the chance of such an accident, but you should also have an oversize filler plug so that excess water can readily escape from the tank around the hose nozzle. This precaution makes the tank completely safe.

Berths and shelving are best made of plywood attached to the hull by gluing and nailing the edges to long simple strips of wood which you have previously fastened to the boat in the same manner. Avoid scrolled or tightly curved trim lines; they are hard to fit properly with mouldings. Excellent trimming strips are available in anodized aluminum, stainless steel, and wood veneer rolls. These latter are made in a wide variety of woods and can be fixed to the raw edges of the plywood with contact cement. Be certain, if you use aluminum, that it is the anodized kind. Even then, it will eventually wear through the protective surface and begin to oxidize, but you should get several years of good service from it before this takes place.

**Skins and Planking**

Now that we have accounted for the fundamental skeletal structures in the boat, we can consider the overall hull surface, which may be wood, metal, or reinforced plastic.

Planking or "skin," the general term which includes any material used

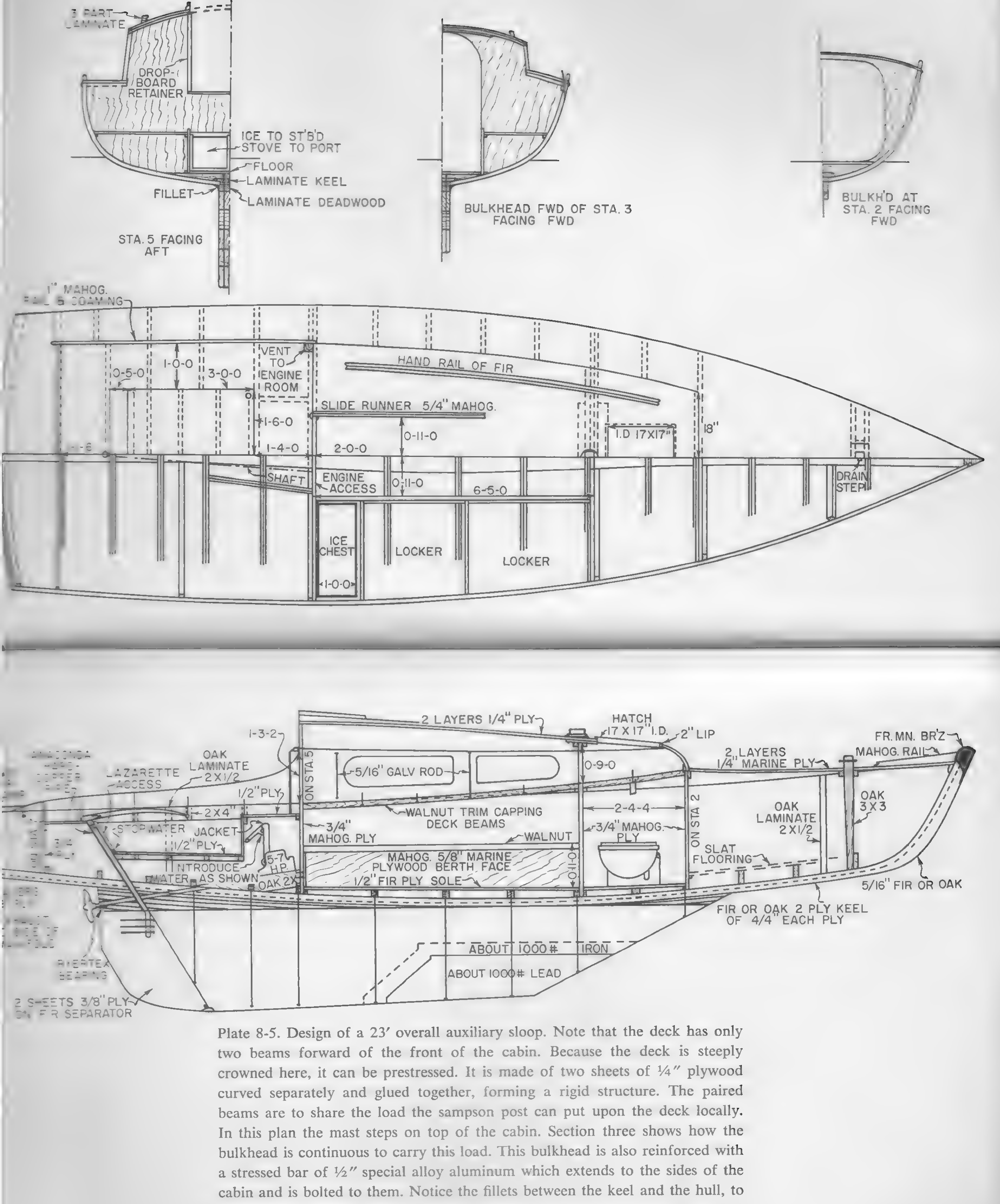



Plate 8-5. Design of a 23′ overall auxiliary sloop. Note that the deck has only two beams forward of the front of the cabin. Because the deck is steeply crowned here, it can be prestressed. It is made of two sheets of ¼″ plywood curved separately and glued together, forming a rigid structure. The paired beams are to share the load the sampson post can put upon the deck locally. In this plan the mast steps on top of the cabin. Section three shows how the bulkhead is continuous to carry this load. This bulkhead is also reinforced with a stressed bar of ½″ special alloy aluminum which extends to the sides of the cabin and is bolted to them. Notice the fillets between the keel and the hull, to form a little reverse curve. This cuts down a bit of the wetted surface, but, more important, affords an easy transition for the fiberglass covering. These boats are also molded in fiberglass altogether, with no wood in their basic hull construction. On the after side of the main bulkhead, extending from the top of the coaming to the bridgedeck, are ventilators for the engine.

to form the hull, serves the primary purpose of keeping water out of the boat, and secondarily contributes to the shape and strength of the entire assembly. You will see from this that, in a caulked, planked boat, an individual strip of planking which needs repair weakens the whole boat more than a local area that has been damaged in a boat where each part of the skin is securely bonded to its adjacent parts. Moreover, in a caulked boat, the strength of each strake is shared to some extent by its neighboring strakes because of the pressure of the seam edges against one another when the wood is fully swollen. For this reason, it is bad practice to drive a caulked boat when she has just been launched and her seams are not yet tight. Under these conditions, the planks cannot lend support to one another; each plank can only transmit strains along the frames to which it is fastened. This is a condition which loads the fastenings far more than normally and tries to apply a splitting force to the frames themselves.

The most common type of caulked planking is the carvel, or smooth-skinned boat. In the small sizes, which we're considering here, and in boats under fifty feet in length, a serious problem can arise from over-caulking the seams. The force of swelling wood is almost irresistible—it has been used, in fact, to separate "frozen" metal parts—and if too much water-absorbent material is driven into the seams of a dried-out boat the pressure from swelling becomes even greater. Because of this, you must be careful in filling gaping seams to work only narrow twists of cotton into place, hand tight. Use a wide-bladed, blunt putty knife or spatula, particularly if the seams already contain some caulking, and do the greater part of your space filling with seam compound. Use a grade of seam compound suited for the area of the boat where you are working, that is, for above or below the waterline. Never use a hard glue type of filler in a boat with caulked seams.

Contrary to popular belief, it is not possible to keep the seam from opening and closing in a boat constructed with space between the planks. The seam compound should be puttied in to fill the space completely and work itself against the cotton; then, using the corner of your putty knife, which ought to be just barely filed round, you can scoop off the surface until it is below the edge of the wood. When the planking has swollen, the seam compound will be flush. Sometimes you will see boats where the compound rises above the seams in ridges the full length of each plank, even when the boat is out of water. This is a symptom of hasty workmanship and, while the only objection to it is an aesthetic one, such practice has always been associated with badly built boats in which putty was substituted for finish work. Such an appearance can seriously hurt the market value of your boat.

If, after the boat has had a week or two to swell, she still leaks, you have to do some thinking. Certain hard woods, such as yellow pine, Madeira

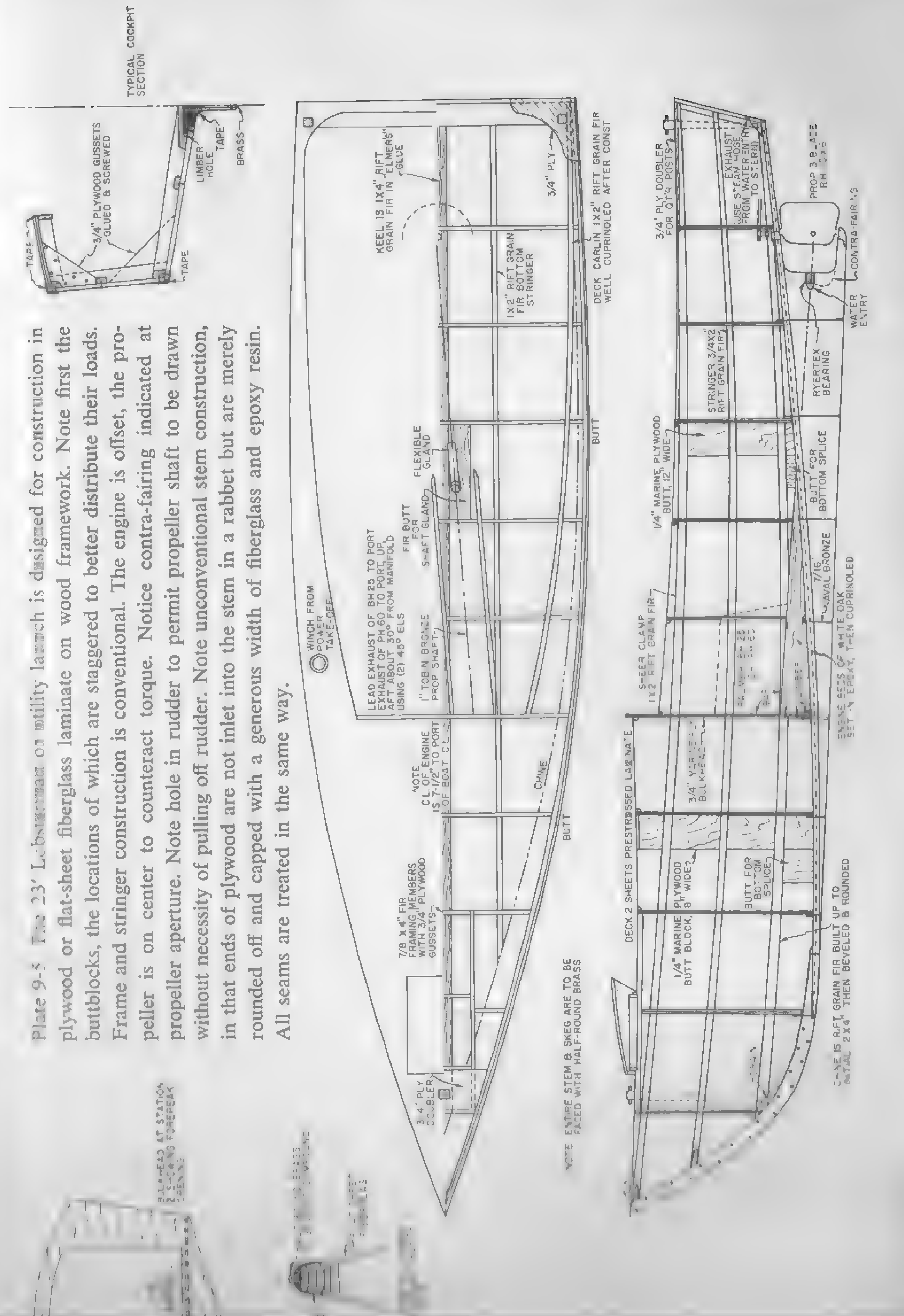



Plate 9-5 The 23' Lobsterman or utility launch is designed for construction in plywood or flat-sheet fiberglass laminate on wood framework. Note first the buttblocks, the locations of which are staggered to better distribute their loads. Frame and stringer construction is conventional. The engine is offset, the propeller is on center to counteract torque. Notice contra-fairing indicated at propeller aperture. Note hole in rudder to permit propeller shaft to be drawn without necessity of pulling off rudder. Note unconventional stem construction, in that ends of plywood are not inlet into the stem in a rabbet but are merely rounded off and capped with a generous width of fiberglass and epoxy resin. All seams are treated in the same way.

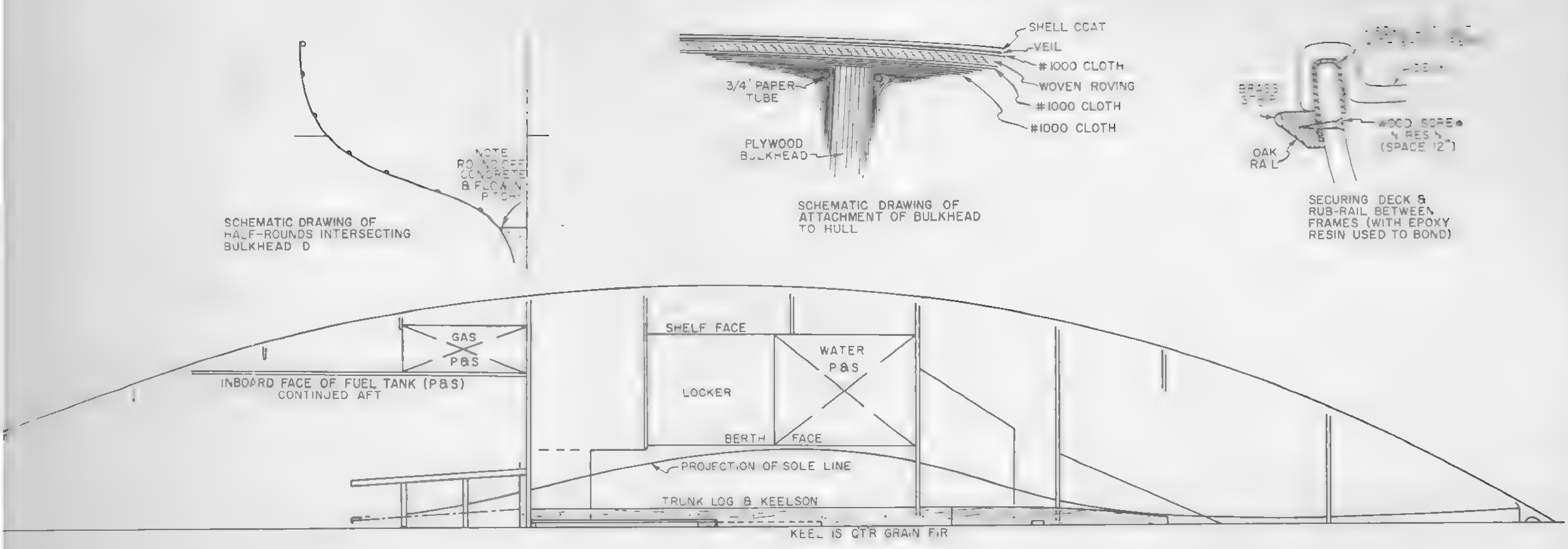
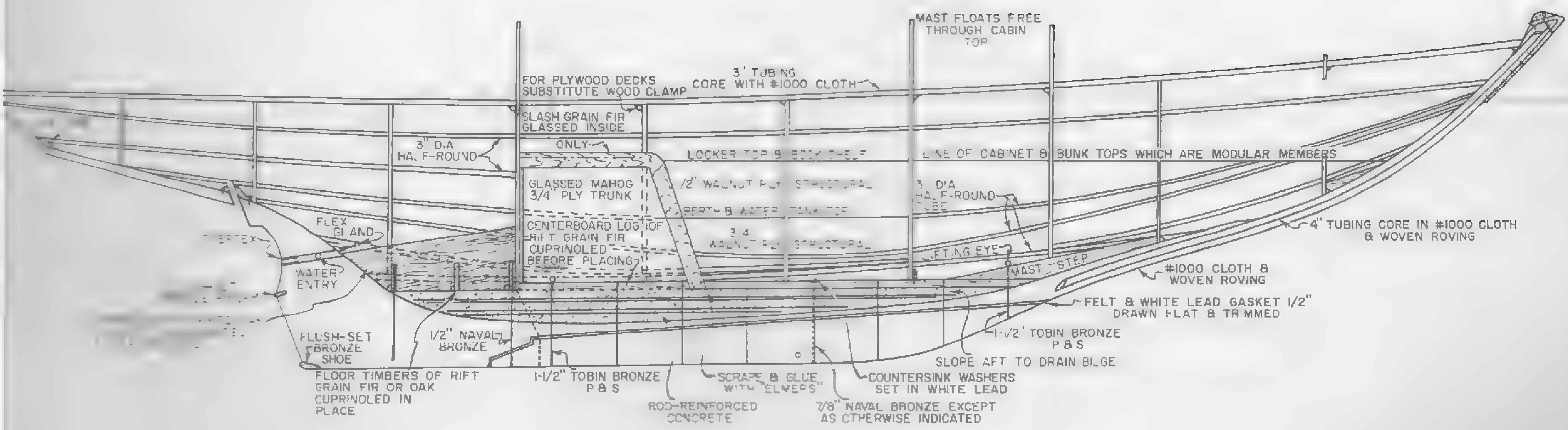
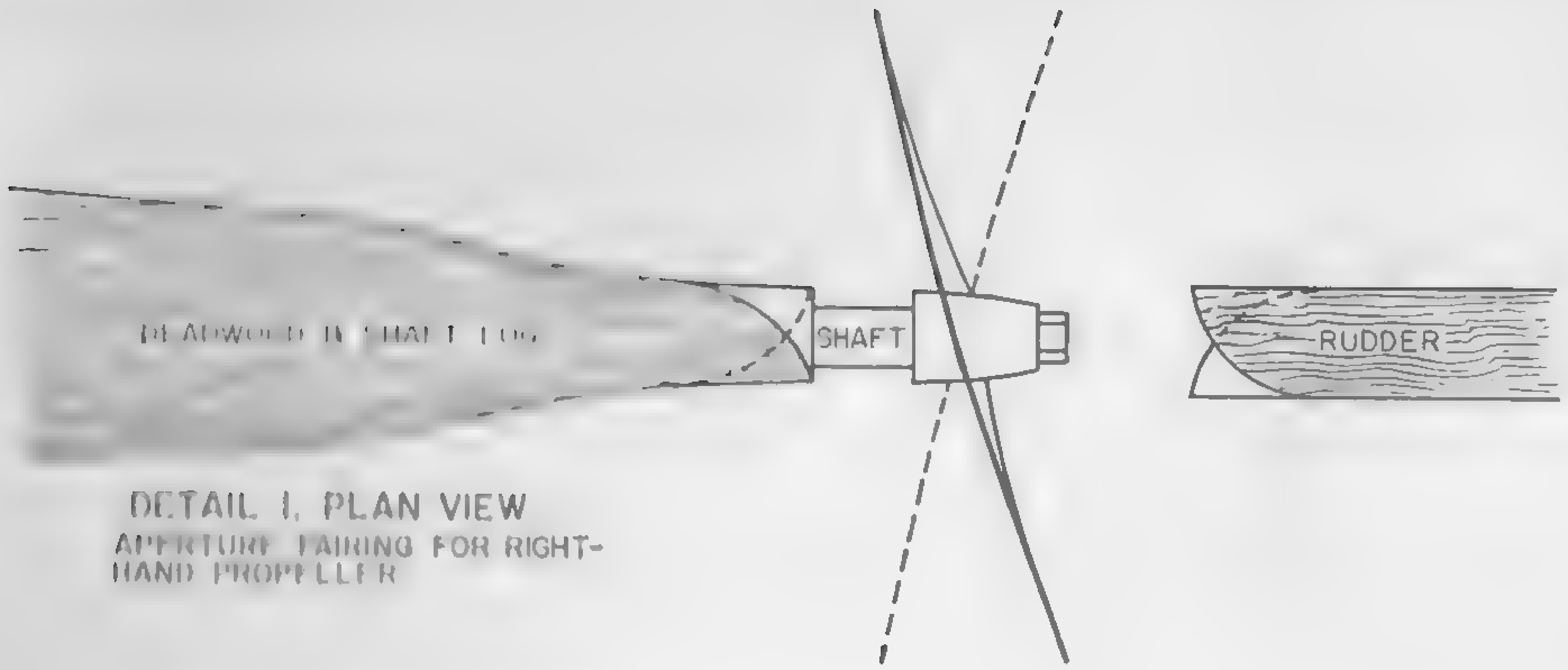
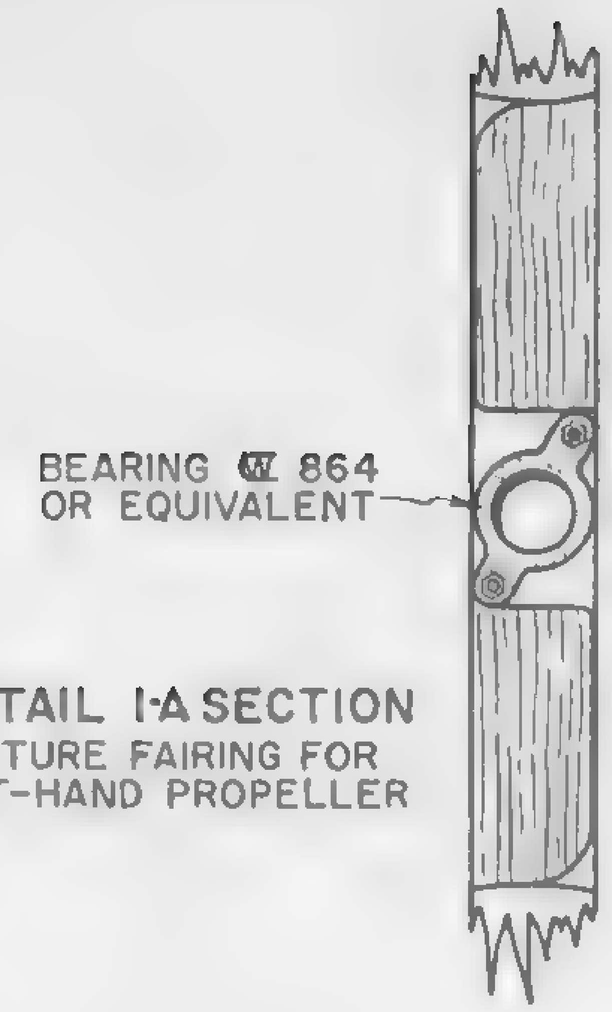



Plate 10-5. A fiberglass-molded auxiliary yawl with centerboard. This shows a simple method of building a single skin, or monococque, fiberglass hull with bulkheads and longitudinal members supplemented by light-weight molded stringers. Note the schematic hull and bulkhead drawing. Note also the reinforced concrete to take keel bolt loads without the expense of building dense fiberglass-reinforced plastic. The use of wood in this design is elective, not necessary. Wood simplifies making certain attachments, such as mahogany bulkheads and berths.

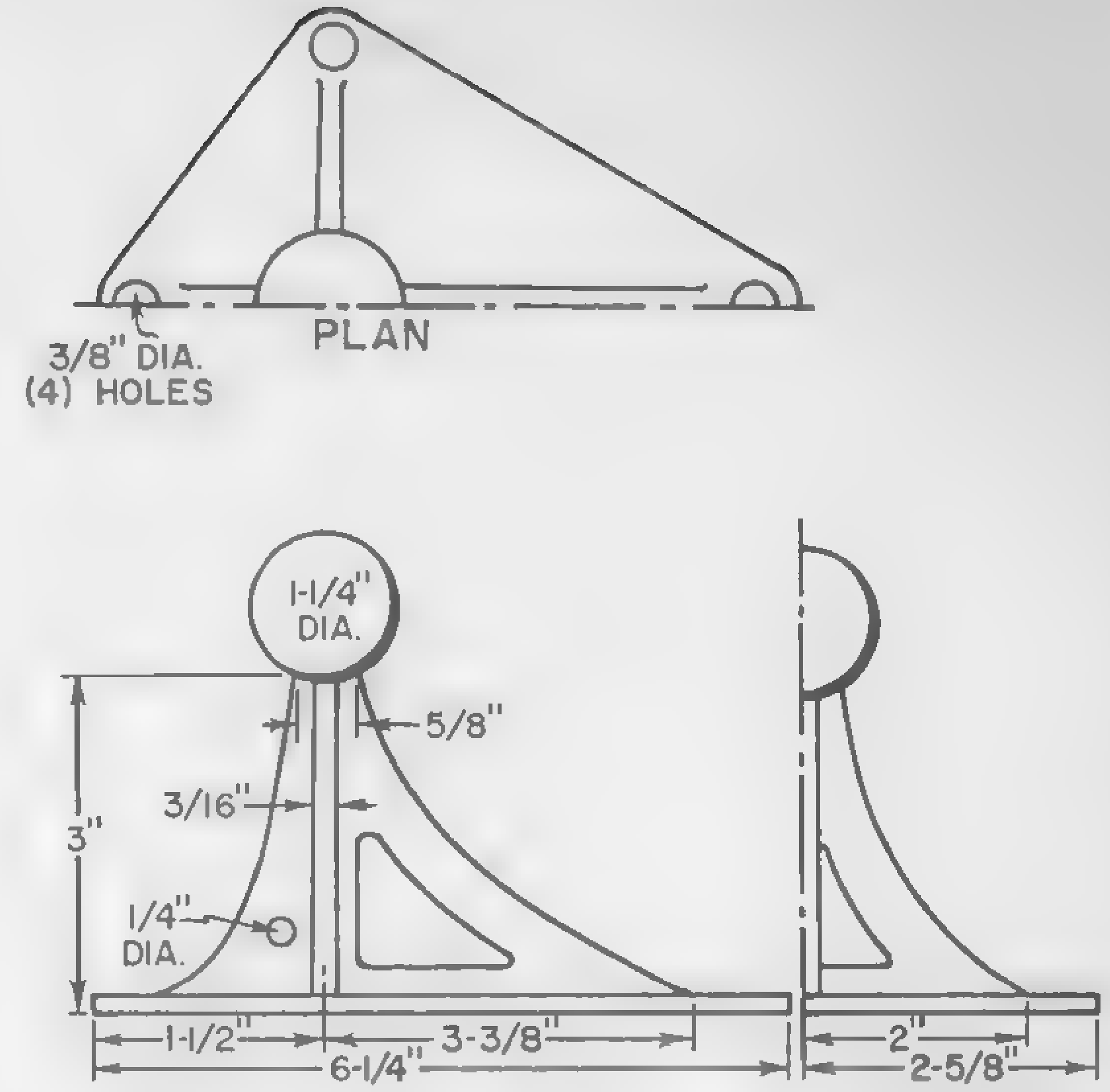





DETAIL 1. PLAN VIEW
APERTURE FAIRING FOR RIGHT-HAND PROPELLER

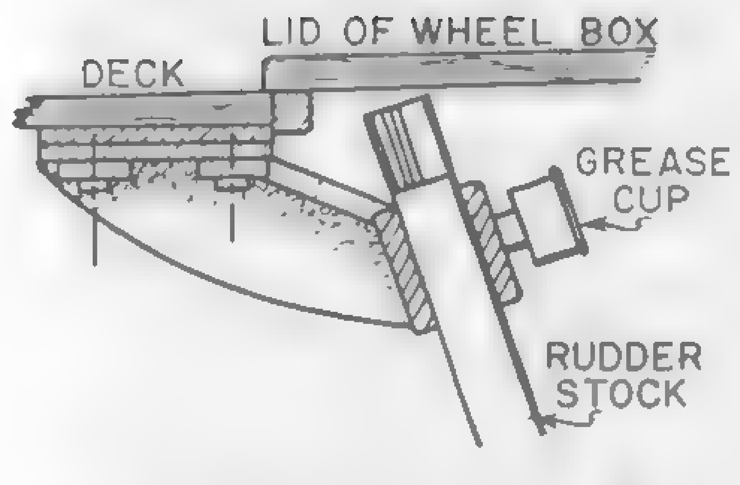



DETAIL 1-A SECTION
APERTURE FAIRING FOR RIGHT-HAND PROPELLER

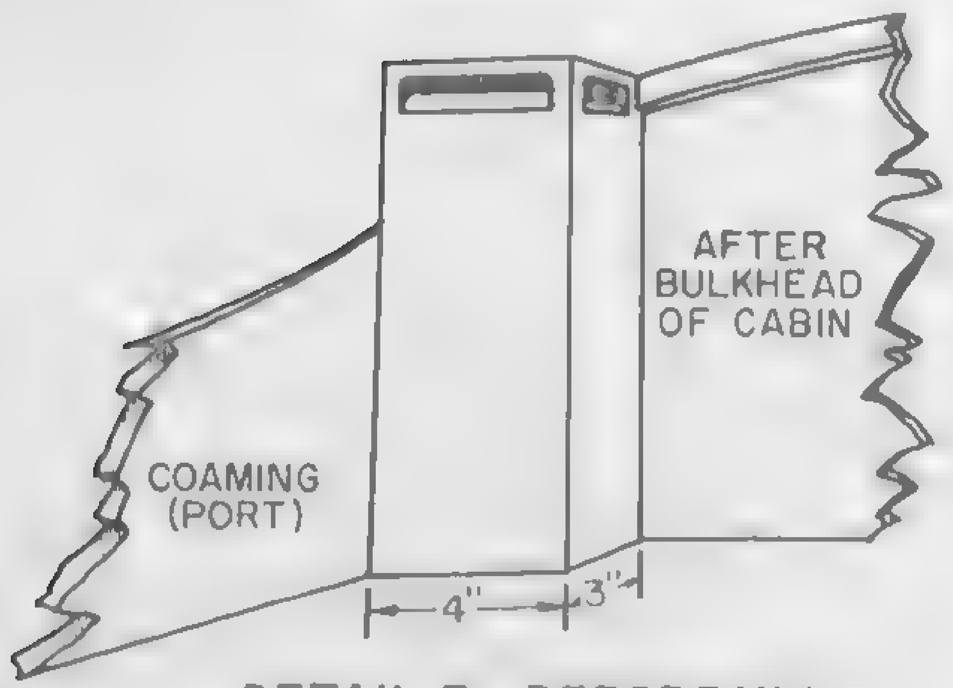



DETAIL 2. ELEVATION HALF-SECTION
DECK FITTING FOR STAYS'L BOOM ONE PIECE CASTING; MAGANESE BRONZE-MAKE ONE

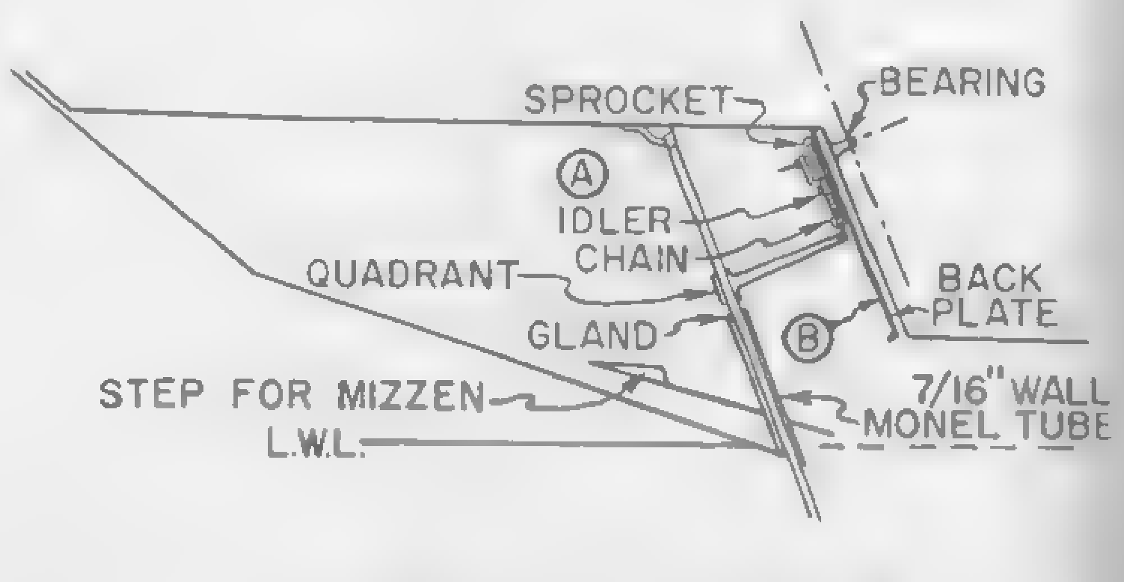
Plate 11-5. Detail drawings showing typical methods of propeller fairing, steering wheel installation, ventilator for engine-room installation, rigging attachments, and fireplace gimballing.



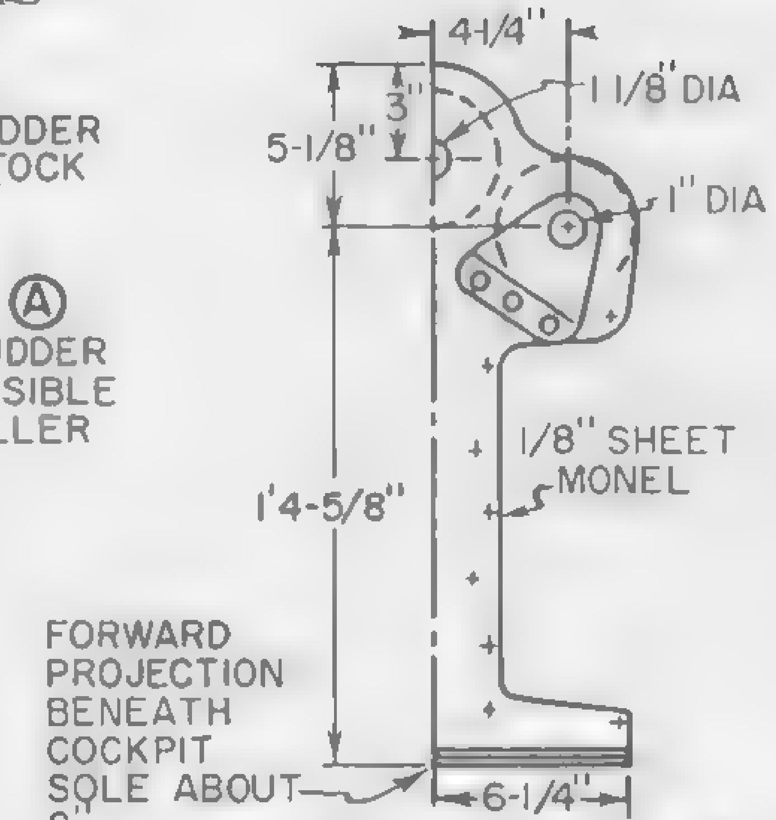

DETAIL 4. NOTE (A)
BEARING, TOP OF RUDDER STOCK, HEAD ACCESSIBLE FOR EMERGENCY TILLER



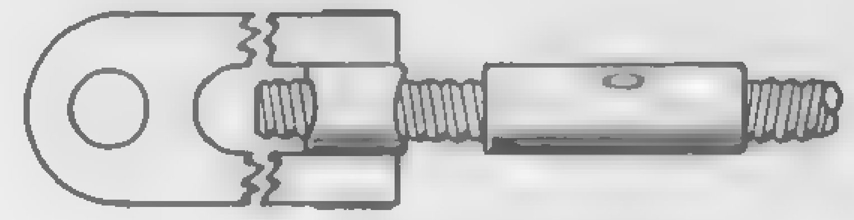

DETAIL 3. PERSPECTIVE
SKETCH OF ENGINE ROOM VENTILATOR MAKE TWO; ONE PORT, ONE STARBOARD



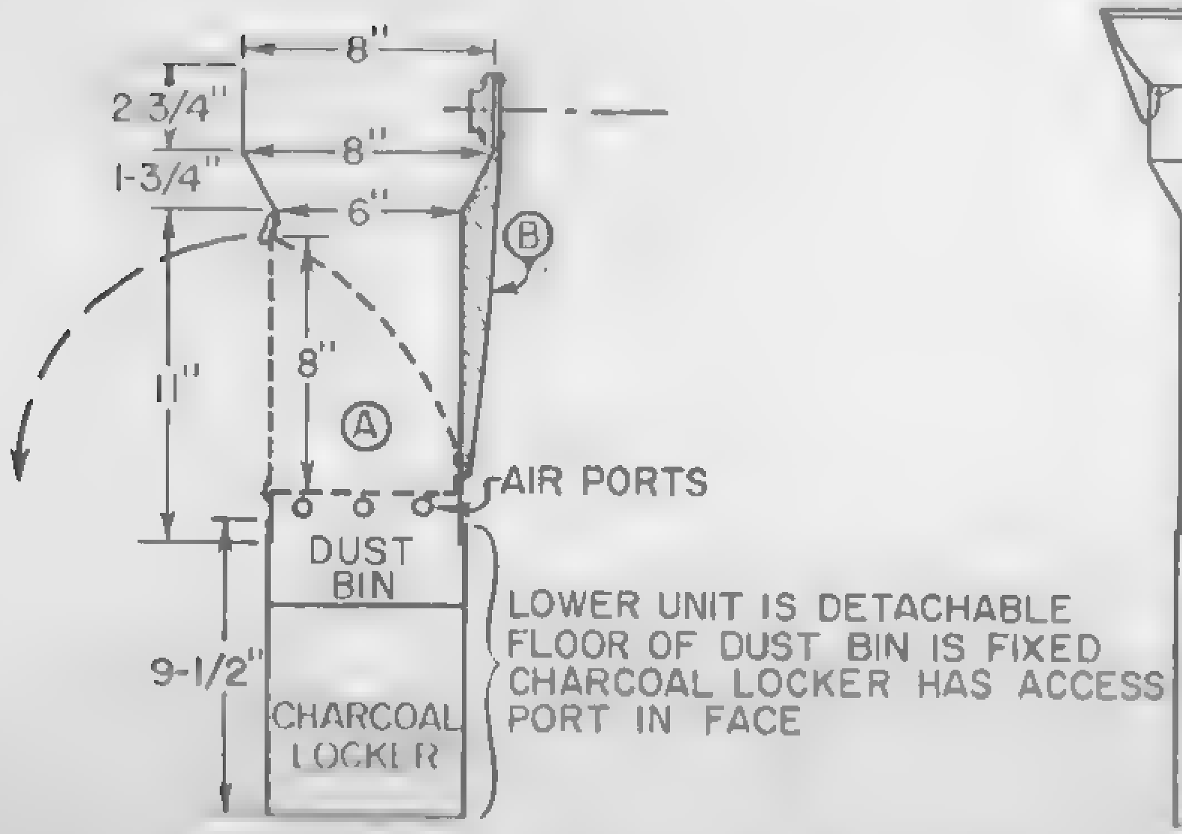

DETAIL 4. ELEVATION
STEER GEAR: QUADRANT, CABLE, SPROCKET & CHAIN

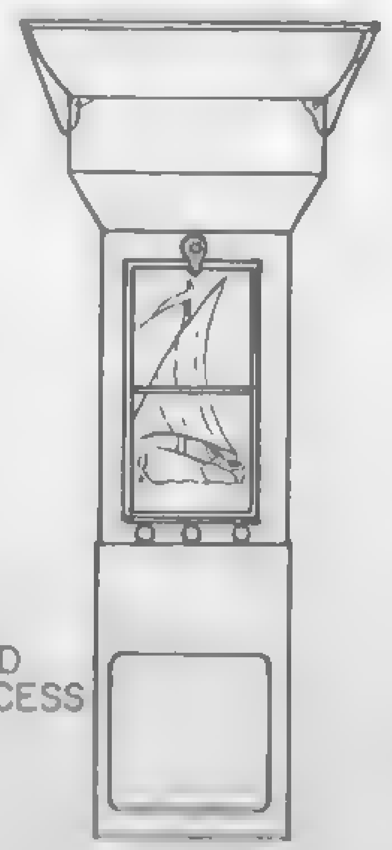



DETAIL 4. NOTE (B)
HALF-SECTION
BACK PLATE FOR STEERING GEAR

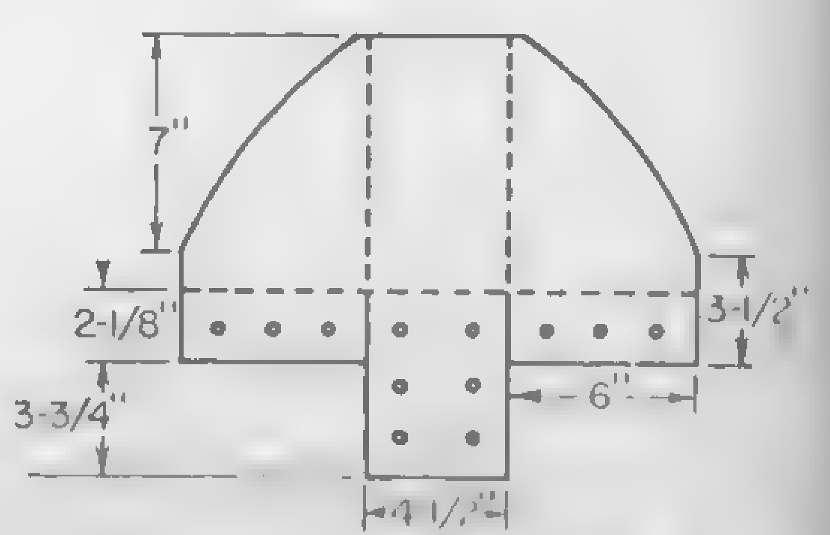


DETAIL 5. SKETCH
HERRESHOFF TYPE OF TURNBUCKLE, MONEL ROD 8 SHEET

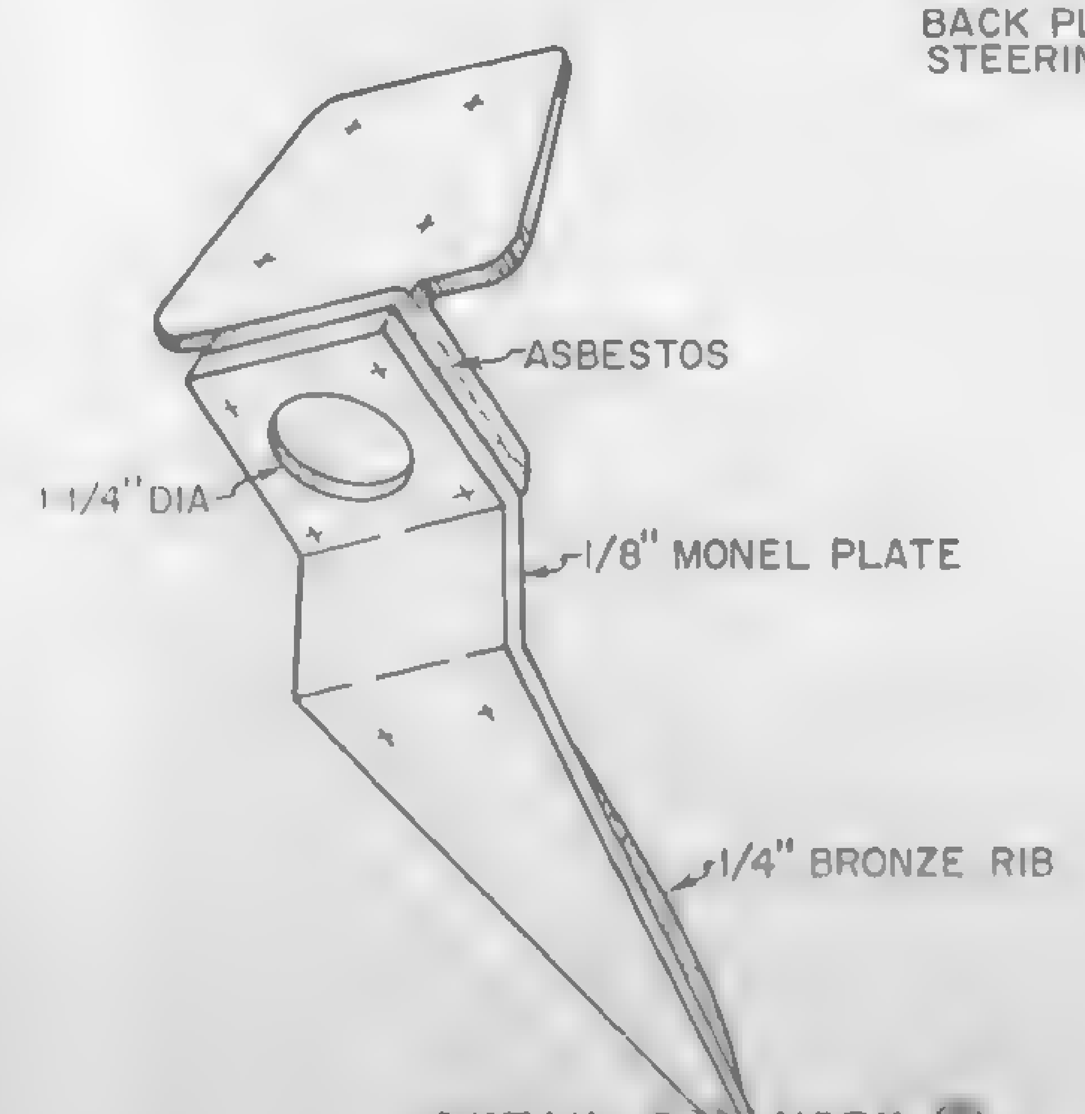


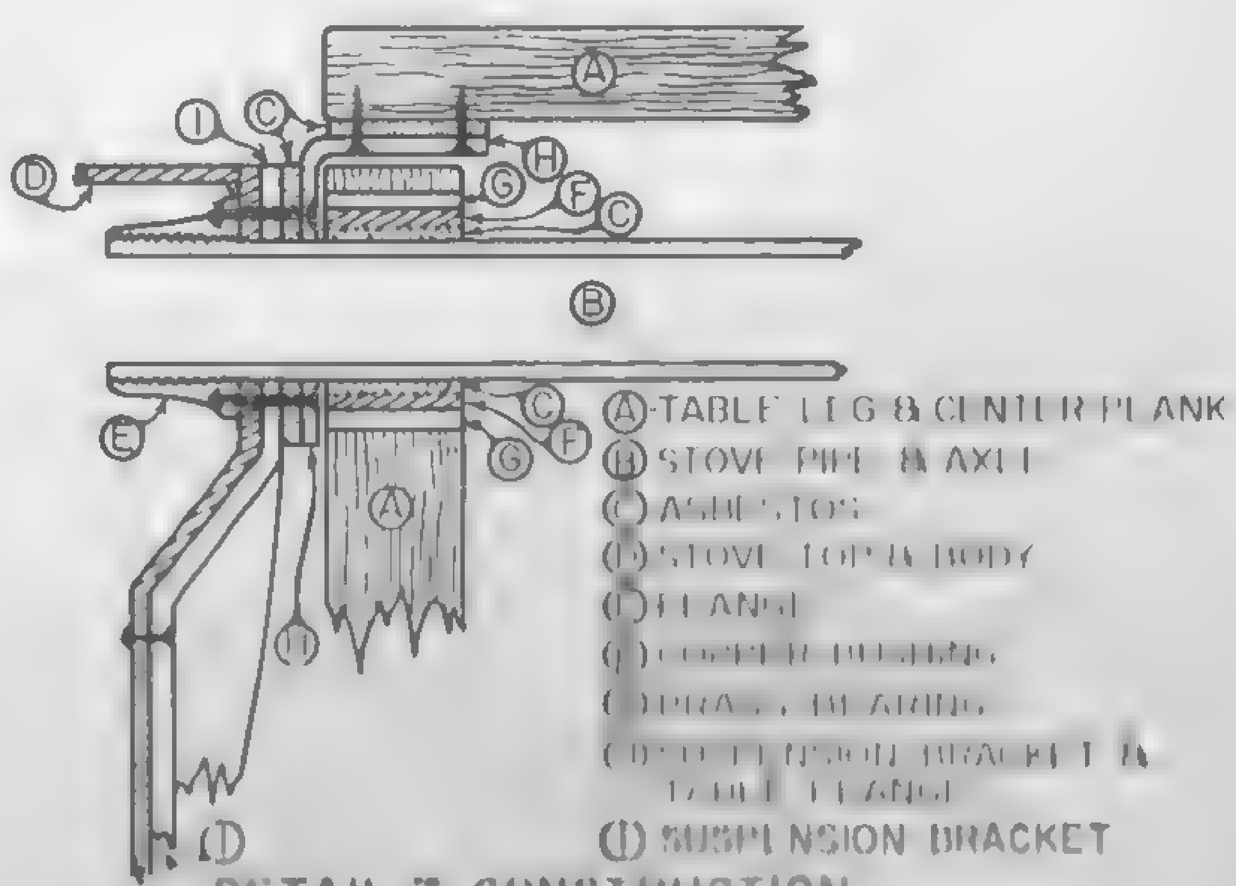
DETAIL 6. ELEVATION
STARBOARD SIDE OF GIMBALLED CHARCOAL STOVE 1/8" SHEET MONEL
FACE OF CHARCOAL STOVE ... AFTER WALL SHOWING ... DOOR, TOP RAIL ...




DETAIL 6. NOTE (A) PLAN
PATTERN FOR FIREBOX DRAW, ... MONEL BEND ALONG DOTTED ... NOTE BOTTOM OF DRAWER WILL BE DOUBLE THICKNESS




DETAIL 6. NOTE (B)
PERSPECTIVE SKETCH




DETAIL 7. CONSTRUCTION ELEVATION SKETCH
STOVE PIPE MOUNT & TABLE AXLE ASSEMBLY

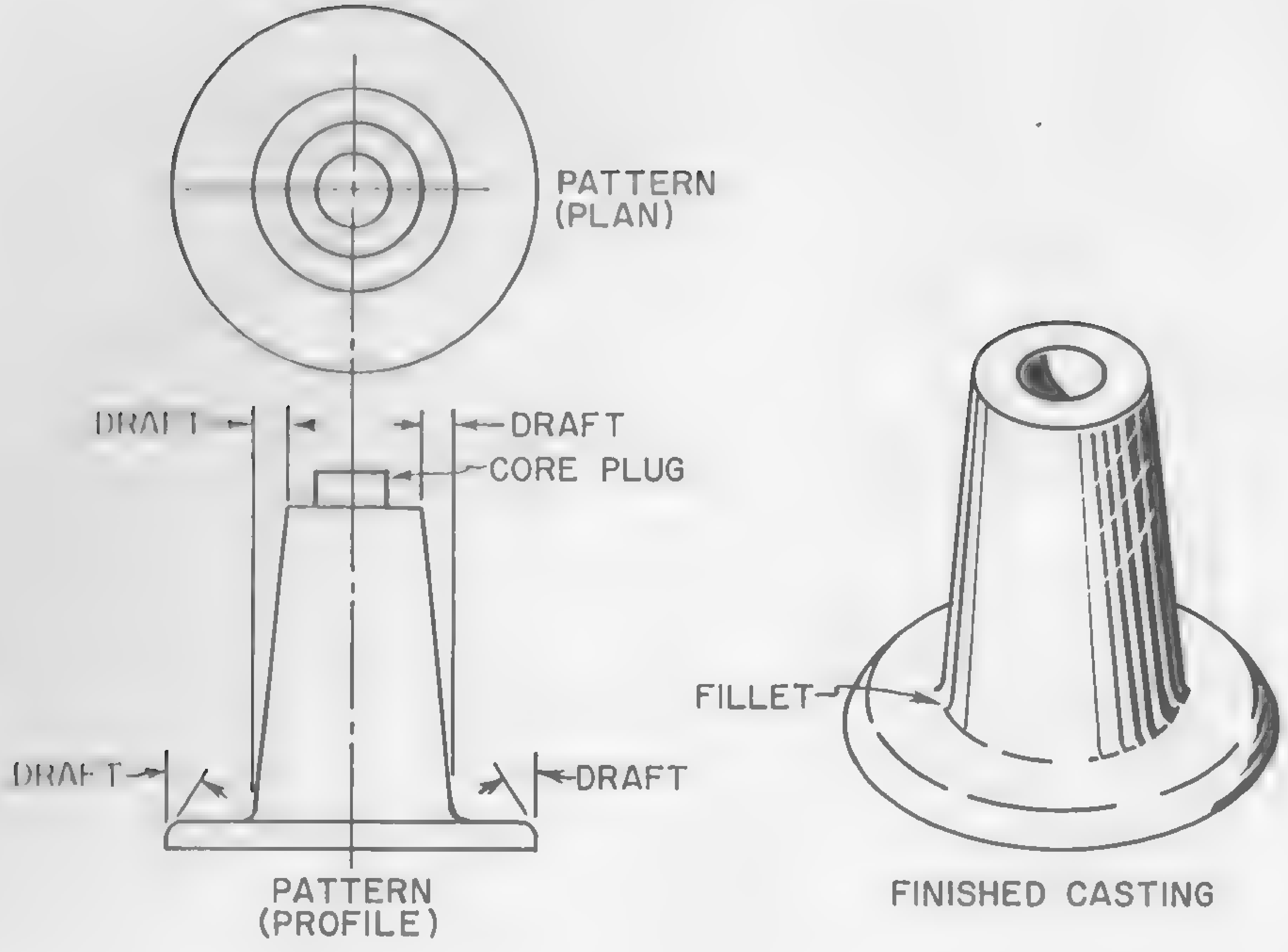
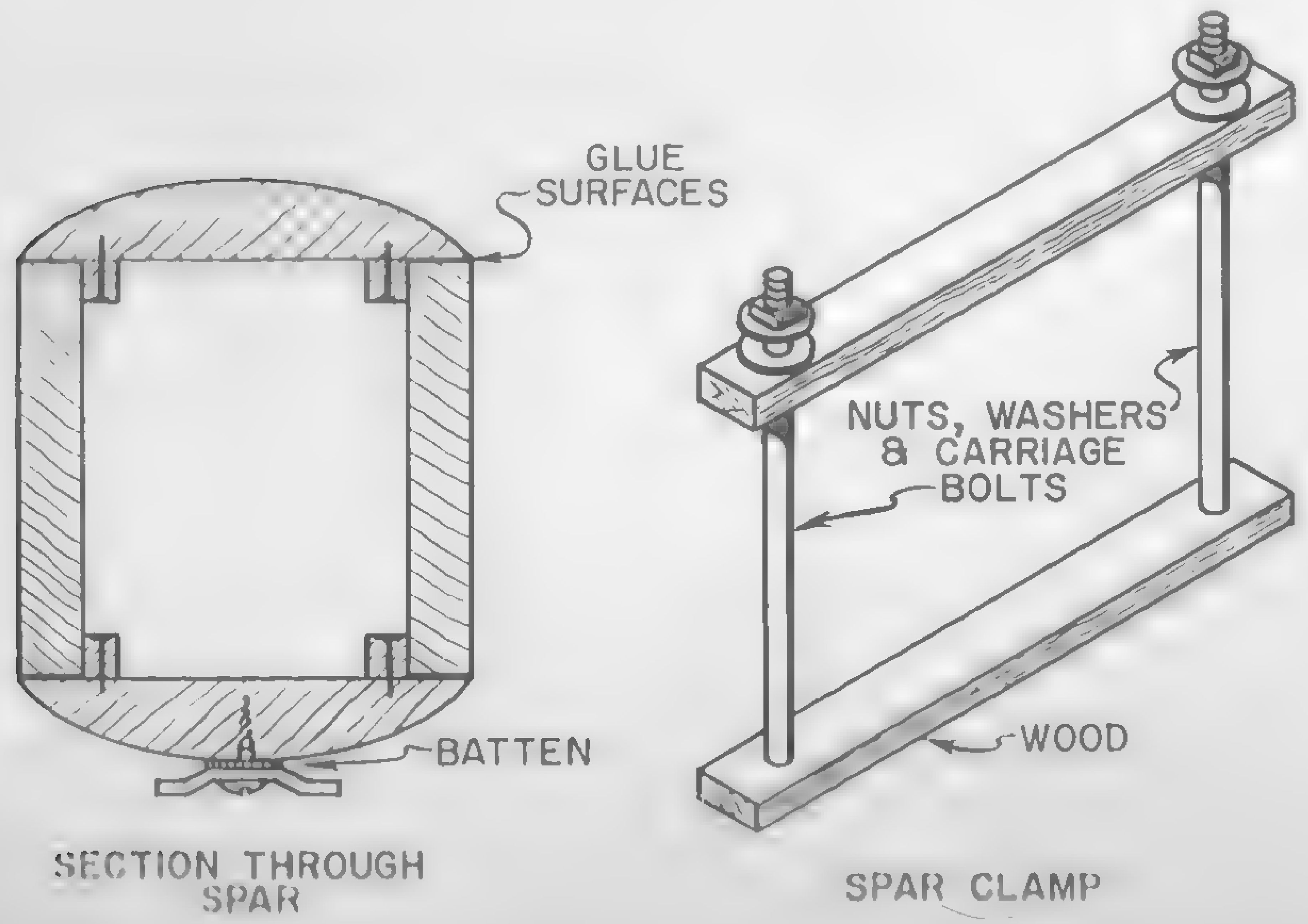



Plate 12-5. Example of casting for stanchion base.

Plate 13-5. Typical spar section of home-built spar-gluing clamp.






mahogany, and oak, require a long period of soaking before they swell. Most types of teak are so oily that they do not swell at all, while cedar, fir, and the soft mahoganies reach their water absorption level in days. Observe whether or not the leaking shows a pattern of decreasing, or whether it seems to remain at the same amount daily. If you have to search for the leak, enlist the aid of a power bilge pump and keep the bilges completely drained until you locate the seam or opening. Then note its position by landmarks you can find outside the boat. For example, the leak may be on the starboard side, forty inches behind the after edge of the mast, second seam from the keel. On no account except real emergency should you attempt to caulk from the inside of the boat. Seams are tapered and have the apex of their angle on the inboard surface of the planking. Caulking from the inside may temporarily stop the water but will ultimately aggravate the leak. When you recaulk, first remove the old compound and cotton for a foot or so either side of the leaking area. Dry up the excess water and recaulk, tapering the new cotton out against the cotton at the ends of the area you are reworking.

Strip-plank boats rarely leak, for not only are the strakes in intimate contact with one another, but they are glued and closely fastened. These strakes are nearly square in cross section, and shrink and swell but little. Because of this, when a leaky seam develops, you can safely caulk it with "Elmer's" or Weldwood waterproof glue or resin that has been thickened with chopped fiberglass or filler. A particularly good kit of epoxy resin paste is called Titan-Tite. Other uses of this kit will be discussed in the fiberglass and resin section, but the pastes of resin and catalyst can be mixed in very small amounts and spatulated into the seam.

Batten-seam boats usually do not leak until the glue cracks from damage, age, or vibration. When such leaks occur, it is best to saw and chisel the batten away from the area of leakage, thoroughly dry the wood, and scarf a new batten fillet into place.

Metal boats and reinforced plastic boats sometimes leak from pinholes, but for considerably different reasons. Pinholes in metal boats are from corrosion or electrolysis, while those in plastic boats are from poor construction. The cure for each is the same: clean up the hole so there is no dirt or grease present (acetone is good for this) and putty with epoxy paste, reinforced with chopped glass if the hole is larger than about ⅛″.

The boat which is usually most difficult to repair is the lapstrake boat. When these develop leaks it is generally because the clench nails or rivets have worked loose, due to years of swelling of the wood. You will have to scrape the seam with a sharp, narrow instrument like a hacksaw blade, then force in elastic glue, such as Sealer 700. When this sets up, you should tighten the fastenings. If the leak persists, you must repeat the treatment until you have conquered it.

### *Major Skin and Planking Repairs*

Many amateurs are seriously afraid to undertake the replacement of a section of planking, but with a little care and attention to craftsmanship it can be a simple task. In caulked, carvel boats it is easiest to remove the damaged strake at the points where it attaches against butt blocks. These are the end-to-end joinings of the pieces of a single strake. If the strakes are in one piece from bow to stern, you should cut the section out of the plank in such a way that its ends come between frames instead of on them. This will enable you to use butt blocks in the rebuilding of the plank so that you can obtain a long, watertight butt which would be impossible over the narrow surface of a frame. Be sure to locate the cut-offs in areas where your access for installing butt blocks will be easy, even though this means making quite a long replacement strake. Keep the ends of the cut planks from springing out by screwing short little cross sticks of scrap material across the inside of the planks fore and aft of the line you intend to saw. Allow about eight inches between these cross sticks and your cut, so you will have room to fit the butt block.

When the damaged area has been removed, and the old caulking scraped away, select a piece of rift grain material of the same thickness as the remaining planking and mark it with a pencil so it is the same area as the outside edge of your cutout. Remember that carvel planking is planed so that the seams form a v and you will understand why you must use the outside measurement. The butt blocks, which should be about sixteen times the thickness of the planking in length, may have to be planed in curves on their outboard surfaces to let the plank take a fair curve. You can check this by trying the plank held only by screws, and not bedded into place until you're sure that the curve is right.

If the new strake appears satisfactory, disassemble all its parts and put them back together in a dense elastic bedding compound. Dolphinite is excellent for this work. Remember that the planking must swell and shrink, so don't attempt to make a rigid bond. Caulk as described in the section preceding this one.

Replacing planks in the turn of the bilge and at the garboard will require the use of thicker material; in this area the planks may be planed in concave-convex form. To shape these planks, a large gouge sharpened from inside the blade and a curved sole plane are necessary. Where the garboard strake seats against the keel, there may be quite a bevel. Unless you are a skilled woodworker, leave this particular task to a professional.

Strip-planked boats can be repaired in a variety of ways. To duplicate a section of a strake in the same manner we approached the caulked carvel boat, you will need a keyhole type of hacksaw or a daggersaw with metal cutting blade because there will be many fastenings to sever. Moreover, because these fastenings are important, structurally, it is not wise to attempt to replace a large area of damage with glue bonding alone. In such a case you must rebuild stepwise, as a bricklayer lays tiers in a wall; but make the overlaps of planking of generous size, at least six inches, to allow ample distribution of strength. Strip-built boats are assembled with hard glue, and "Elmer's" or Weldwood waterproof glue should be used.



It is important, too, that the planks do not meet one another in butt joints. They must be scarfed or angled together to make them waterproof. Such scarfs should be long—eight times the thickness of the strake is a safe proportion. Set them in glue and hold them with a fastening midway in their length.

A strong, simple method of repairing hull damage to a strip-constructed aluminum, iron, or fiberglass boat is by the use of glass mat and resin. (See Photos 1-5, 2-5, 3-5, 4-5.) With a coarse, open-coat aluminum oxide paper on a rotary sanding machine, taper the hole from inside and out. This taper need not be very great. It serves as a countersunk area for the edges of the fiberglass patch and increases the mechanical adhesion of the bond. Next, cover the hole from inside or out with a sheet of wax paper, or polyethylene, held firmly to the hull by a scrap of thin plywood, pressed board, or sheet metal. This is generally easiest done from inside on metal and fiberglass boats; you can brace the material right across from the opposite side of the hull.

Next, layer by layer, build up a filler of resin reinforced with fiberglass mat. If the damaged area is very large, you may have to support the first layer of material by bridging the hole with it before you insert the paper or polyethylene-shielded board, then use this assembly to hold the mat in place until the resin cures. Be careful to build out accurately to the contours of the hull, so that no sign of the patch will remain after you have sanded and painted the surface. An excellent way of checking for pinholes and faulty areas is to mix pigment with all your resin, then illuminate the patch from outside and inspect it from the dark interior of the boat. If the required thickness of such a patch is very great, you can insert a piece of balsa wood to take up space in the middle. In a boat with one inch planking, the inner and outer thicknesses of glass flanking, the balsa can be about $\frac{1}{8}''$, so that $\frac{3}{4}''$ is balsa.

Repairs to lapstrake boats are similar to repairs to carvel construction, if wood is used, but here the caulking, instead of being pressed between the edges of the planks, lies between their overlapping sides. When you have cut out the damaged area, having staggered the cuts so that no adjacent repairs will butt in the same line, examine the old pieces to see where the groove for caulking has been cut. Make the grooves in the new planks fall along the same line. You will find you have to scarf lapstrake planks. It isn't possible to make adequate butt block joints in such shingle

type of construction. For this reason, if the boat can be painted so that repairs don't show, it is easier to use the fiberglass-mat method described above.

**Ballast**

Except in metal boats, where the ballast can be conveniently located inside the hollow keel, the proper place to hang any considerable weight is outside the boat. The reason for this is that when the boat grounds, or is handled in the boatyard, the ballast puts great strain on the hull. This situation holds true for inside ballast, laid upon the planking, or put into a hollow fiberglass keel. The latter situation is particularly bad, because, in accidental grounding, the entire weight of the ballast delivers a sledge-hammer blow against the relatively thin wall of glass and plastic. No material can survive much of this sort of treatment.

Inside ballast, such as is generally used for trim on power boats and stability in shoal-draft sailboats, should be firmly chocked down on a special platform of its own. A piece of plywood, soaked with wood preservative and fitted between frames, will distribute the load of such a weight over several planks at a time. However, these planks, too, should be sound and well saturated with preservative. To keep the ballast from shifting, once you have the right amount in the proper location, you can pour hot pitch over the separate pieces while they are in position on the board. This will firmly anchor them, although you will have a heavy load to lift when you decide to remove each unit board. The board itself can be retained in place by a shallow wood cleat screwed at several points into the hull. The hot pitch treatment will also keep iron ballast from "bleeding" into the bilge.

Outside ballast, regardless of its nature, should be set against the hull in a gasketing compound. This is necessary to cushion and fill the many small imperfections between the two surfaces. Such cushioning not only aids watertight integrity, but evenly distributes the loads from the separate keel bolts. The gasket is best made of very heavy felt. Use three or four layers, painting each with white lead before laying on the next. Asphaltum or hot tar is a good alternative, but messy to apply. Don't forget to use a torque wrench to set up the keel bolts or you may find that, due to uneven tightening, one lone bolt is doing all the work.

While some general attention has already been given to fastenings, in the "Appendix," you will find a table of commonly used fastening sizes for different thicknesses of planking. It is important to reiterate the preparation for all fastenings, however. They should be drilled for, if you want them to develop their proper holding power and avoid damaging the wood. Screws should be lubricated before they are set, and beeswax is a fine material for this task. Ordinary household soap will do to lubricate screws

Photo 1-5. Damaged hull, broken along sheer line.

Photo 2-5. Broken area cut away to leave "clean" edges. Workman holds aluminum plate to provide backing surface for fiberglass repair.

if you have no wax, but soap likes to take up water, which the wax resists. Never lubricate wood screws with grease because this will encourage rot, which will actually feed on the fats in the grease.

Nails patterned on the screw-holding principle are very satisfactory if you are sure you won't later want to remove them. They must be drilled for in the same manner as screws. For special high strength applications, screws and nails are available in Monel. Stainless steel, while very strong, is not to be trusted in a salt-water environment. Monel, on the other hand, has the added feature of being very kind to metals near it in the same salt-water bath.

For general use, silicon bronze fastenings are strong and electrolytically sound. Brass, on the other hand, is never to be trusted around salt water, except when used for doorknobs, hinges and such.

Hot dipped galvanized iron is a good material to use in boats with iron keels. It is strong, holds extremely well, and is inexpensive.

Copper nails and rivets are entirely satisfactory for general fastening use in small boats, but too expensive to use for large jobs. This is not only because of the initial cost to the purchaser, but because many rejects will result from slightly inaccurate hammer blows, which fold the fastening before it's driven home.

**Hardware**

Hardware, such as cleats, portlight mountings, and stemhead fittings can represent a tremendous financial outlay if they are purchased off the store counter. However, there is a far less expensive way to get this gear, if you have some ingenuity and there is a foundry in your area. The secret lies in making your own patterns and buying your cast-bronze hardware by the pound. See Plate 11-5.

There is nothing mysterious about pattern making and, although you won't want to try complicated investment patterns unless you have a complete woodworking shop and skill to match it, some simple carpentry with scrap lumber will enable you to get custom fittings proportioned exactly to your needs.

Most bronze castings are poured in molds and made of tightly packed, fine sand. These molds are in two halves, so the pattern you make must be designed in such a way that the foundryman can force it into the sand, to leave an accurate impression, and draw it out again without disturbing the sand. To enable him to do this, you will have to think about the shape of each part you make, taking care that there are no overly thin parts or undercuts. You will also have to give your pattern a gentle taper, which the foundryman calls "draft," because parallel-sided objects can't be withdrawn from the sand without destroying the impression. Never leave any sudden or sharp angles on your pattern. Round them out with "fillets," the



foundry term for a hard putty fairing with a slight radius. And, finally, if you want a large hole anywhere in the casting you can indicate it with a core plug. The earlier illustration (Plate 12-5) will help you to understand these instructions. However, you should visit your foundryman before you start work. He'll be glad to take a moment to show you the steps in what he does, and he usually has a great collection of stock patterns lying about the shop. You may find exactly what you need.

Red brass castings are satisfactory for cleats, portlight frames, and awning fittings. Such brass is cheap, can be polished up nicely, and is easy to get quick service on, for it is cast very frequently.

For goosenecks, winches, chocks, and other load-bearing devices, ferromanganese bronze is good. It is an unusually tough, corrosion-resistant metal which machines well. It has a dull color, flecked with tiny rust specks. Ferromanganese bronze is only used for special high-strength noncorrosive castings because there is not a great demand for it. Your foundryman may be unwilling to melt up a pot of this metal for pouring unless he has enough jobs requiring such an alloy to make it worth while. For this reason, you may have to wait some time for your part.

Your foundryman probably has a mixture or two of his own which he recommends. Listen to his suggestions; he knows his ingredients and how well they work. You will find that when hardware fails, such as a part in a deck winch or toilet pump, you can often paste up the broken piece and use it for a pattern, having your replacement item cast at a real saving of time and money.

**Fiberglass and Plastics**

The fiberglass-reinforced plastics are the best materials we know today for boat construction. Their advantages were discussed in Chapter 1, but here we shall mention some details about the techniques of working with these products to obtain the best results. See Plates 2-5, 3-5, 4-5, 10-5.

Fiberglass is a term for a material which is available in a variety of forms, ranging from hammermill fibers (used for "filling" resin, to give it strength and body plus anticrazing characteristics) to fabric, mat, and roving. These latter materials are saturated or bonded with resins to give them a wide range of forms and uses. In boat work we can reduce our interests to fabrics, used for hull covering material, and any combination of glass products and resins for actual construction and repairs. Generally, the boat owner will be most concerned with the fabric styled 164. This is available with coatings which make it adhere well to polyester resins. Such coatings go under the trade names of Chrome, Blue Sheen, Volan A, Finish 136, and Garan. Fiberglass mat is sold by weight. It generally contains a resin binder which keeps the strands in place, and also may be coated as is the fabric. Mat and woven roving are invaluable materials for

quickly building up a thick laminate. Some mats are made extremely thin. These are called "Veil" and are used for surface coatings. When Veil is used with clear polyester resin to cover a surface of wood, it appears much like varnish, but lasts infinitely longer.

The resins commonly associated with boat work are polyester and epoxy. While polyesters are broadly used for covering, hull building, and repair work, they are not such good adhesives as the epoxies, and where you need unusually good holding characteristics, such as in repairs over metal surfaces, epoxy resin should be chosen.

The polyester resins are rather thin, straw-colored long-chain polymers. They may be thickened with a variety of additives to make them resist sagging or running. Such additives include aluminum silicate, which, being an airborne material, is physically uncomfortable and dangerous to use. For this reason, the body material is often added at the factory, and such resins are then referred to as "thixotropic." One excellent nonsagging resin is called "Boat Armour." All these resins are designed to be activated by the addition of proper amounts of a second chemical, called the catalyst. The rate of reaction is controlled primarily by an "accelerator" which may be already in the resin at the time you purchase it. Cobalt is generally used for this purpose and it tends to introduce a purple cast to the mixture. The catalyst, and the accelerator, if you must add it separately, should be thoroughly mixed with the resin, or you will not get proper curing. Stir while counting the strokes, to control the mixture properly. Fifty strokes is a good, safe margin for a quart of resin. The time required for the material to set will vary with the temperature and, apparently, with the humidity. You can influence this curing time considerably by the amount of catalyst you add to a given amount of resin. It is useful to add pigment to color polyester resin when you are building a laminate, because it helps make the pinholes which occur more visible. Remember that the addition of such a pigment will, in effect, dilute the catalyst, so you will have to add a trifle more to get the same curing time as with uncolored resin. Be sure to use a pigment recommended by the resin manufacturer. Certain types, such as oil-base colors, may affect the resin's strength or life.

Epoxy resins are extremely high-strength linear polymers which have distinct mechanical advantages over the polyesters for certain applications. Whereas the polyesters shrink about eight per cent of their size when they cure, the epoxies only shrink about three per cent. This means that there is much less chance of a lay-up cracking, distorting, or developing an uneven surface. When adhesive strength, extreme impact strength, or maximum tensile strength must be developed, the epoxies are a logical choice. They are activated by a catalyst, in the same manner as the polyesters. Somewhat higher in price at the present time, their reduced cost will eventually make them competitive with polyesters. Shell Resoline is the one

Photo 3-5. Aluminum backing is taped over damaged area. Fiberglass is built into place.

Photo 4-5. Aluminum plate has been removed. Repaired area is even, hard, and ready to be sanded lightly and painted.

epoxy resin which is water soluble. It should never be used for boat work. Earlier in this chapter the Titan-Tite repair kit was mentioned. This makes the epoxy and its catalyst available in tube form, and they can be used as pastes, mixed together on a piece of scrap paper until they are thoroughly blended, then puttied into place. For small, on-the-spot jobs, this is the most satisfactory package on the market.

Resins of any sort can be applied to the glass material by brushing, rolling, dipping, or spraying. There are some particular solvents and thinners which are important here. Cheap, but entirely effective, is acetone for cleaning brushes, rollers, and spray guns. However, you will find that it evaporates very quickly, so you must keep the container well covered. Toluene, which evaporates more slowly, is a very good cleanser, as is styrene. Styrene, slightly more expensive, is an all-round good thinner for spraying the resins. It is best, if you have the money to invest, to use an external-mix spray gun for resins. This sort of gun introduces the resin and catalyst to one another while they are in the air, clear of the nozzle of the gun. In this way there is no danger of the materials setting up before you can remove them from your equipment.

Some rollers and brushes are soluble in these cleaners. Dynel, particularly, is unsatisfactory because of this. Nylon seems excellent, as are mohair and natural bristle brushes.

**Fabric Surfaces**

This term includes materials like cotton-covered dinghies and canoes, canvas-covered decks, and rubberized fabric hoods. Most of these materials will eventually show damage from chafe, and the quickest way to cover them so they are waterproof again is to paint them with neoprene paint.

When such material has blistered and worked loose, as from a boat deck, which you feel can be reset without being recovered, a good trick is to purchase an old, metal-bodied, large-size medical syringe which will take an irrigation tip. Grind the tip to a point, like a hypodermic needle. Then you will be able to fill the syringe with adhesive, such as activated resin, and inject it beneath the blistered fabric. Hold the blistered area flat, by stacking weights on it, until it is dry.

Where the fabric has been snagged, cut, or torn, it is usually possible to reseat it in resin, using an excess, which will build up along the seam where you can later sand it flush. If the material is injured in an area where it has no support or backing, look up a model-airplane shop or local airfield, and purchase fabric dope. You can patch the tear from inside or out, and although it will show, it will be as good as new. Your patch can be made from airplane fabric. Cut it with pinking shears, so it won't unravel as you work it. Remember that repeated coats of dope will shrink the fabric very tight.



Recovering an old or damaged fabric deck holds no secrets except hard work. You must remove all the deck fittings and rails, then strip off the original covering, down to the wood. A belt sander is good for this, using an open-coat aluminum oxide belt. Try to get a sander with a dust bag on it, or wear a face mask while you work and goggles to keep particles from your eyes.

If the deck under the original covering is too badly deteriorated to take fiberglass resurfacing, you can do a good job by setting canvas in white lead or shellac. Either method is satisfactory.

To use white lead, simply paint it on the deck in a thick, even coat. Use an open-weave canvas, and work it down on the deck with rubber rollers, or by skating on the deck in your stocking feet. The object is to get the white lead to ooze up through the fabric.

With the shellac method, you must paint the deck with thick orange shellac, then work very quickly to lay the canvas before it sets. Only paint a strip across the deck about a yard wide at a time, so there is no danger of it hardening before you're through smoothing it.

Both the white-lead and the orange-shellac canvas techniques require stretching of the canvas. You'll require an assistant for this, a man with good, strong hands. One of you should be on each side of the boat, and you start from amidships, working fore and aft. Stretch and tack just a few inches at a time, carrying the fabric well over the edge of the deck, so you can tack it to the sheer strake. If you put your fastenings into the edge of the covering board, you will surely split it. A staple gun, using non-corrosive staples, is superior to tacking. In boats with flush decks and open cockpits, leave the cockpit until last, then fold the fabric over the edge of the cockpit deck and secure it just as you did at the topsides.

**Spars**

Spars, once built only by men who specialized in their making as in an art, can now be made by anyone with woodworking skill. The reason this technique is now simple is due to the invention of the box-shaped spar and to the excellent glues that are available today. The diagrams give construction sections of two typical spars. See Plates 2-5, 13-5.

For boats of any size, the best wood for sparmaking is rift grain spruce. It is light, very strong, and takes glue particularly well. The perfect glue for sparmaking is Weldwood cold-water glue; because of its excellent properties, you can assemble an entire spar with no fastenings. The spar itself should be closely clamped, when gluing, and must be laid out on a perfectly flat surface. A typical clamp which you can make yourself is illustrated.

The after edge of the spar should be absolutely straight up and down in a fore and aft plane, or it will disturb the line of the mainsail luff. All

your curvature for shape and lightness will be on the sides and on the forward face of the spar. You will notice, in the illustrations, that the after wall of the spar is thicker than the other three calls and that sometimes the track is raised a little from the surface by a thin batten of wood running the full length of the spar. This extra thickness serves to give the screws retaining the track additional wood to hold in. The thin batten, which is not usually necessary, sometimes is added to get extra clearance between the track and mast so that the sail slides don't jam. Don't be afraid to taper a spar quite a bit. A set of typical sections for a thirty-foot spar might be three by four and one-half inches at the deck and foot, the same measurements at the lower spreaders, tapering to two by three inches at the head. Such a spar, made of spruce, might have the walls a full 3/8″ thick except for the after wall, which would be 5/8″. Where the spreaders and tangs attach, this spar would have doublers of the same spruce glued inside, about twelve inches long. These doublers would never fill the hollow in the spar from wall to wall, like a plug or bulkhead. They are just used to gain additional thickness for fastenings. Any plug or bulkhead structure is bad practice except for the plugs at the foot and the masthead, for when the spar deflects or swells they will surely split it apart. The plugs at the ends need only be ten or twelve inches long. The one at the foot can extend an inch below the spar to act as a tongue into the mast step. The one at the top will be mortised out to take the halliard sheave. The plug in the bottom of a mast should be made with a large drain hole running right through it, so that any moisture which enters the mast cannot remain to cause rot. It is excellent practice to cap the mast with fiberglass-reinforced plastic, and also to line the mortise for the sheave with this material. A wide band of FRP around the foot of the mast will keep the wood from splitting, here, and another band where the spar comes through the deck or cabin top will take the chafe at these points.

The most common failure of masts is drying out and splitting along the glued seams near the deck and foot. The mast works a lot at these points and, after many years, an improper joint will give out. The repair is most easily made by using a power saw to open the seam, then regluing it with an inlay of spruce, called a "Dutchman," which tightly and accurately fills the newly cut slot. A second, very good technique, is to clean out the old glue thoroughly, and work in a sliver of fiberglass tape saturated with epoxy resin. This is another excellent use for the Titan-Tite kit.

Frequently the screws retaining the sail track or mast fitting work loose. If the wood is rotted, carefully cut it away and fill the area with a patch of glass and epoxy paste. If the screw holes simply have loosened with age, you can remove the screws, dip them in epoxy resin, and reset them. They will be quite permament.

When a spar breaks through accident, but is in good physical condition



in other respects, it is necessary to scarf it together. While temporary repairs can be made by wrapping it with fiberglass tape and resin, and this can even be left permanently, if you desire, such a repair is hardly seamanlike. A single, long, accurate scarf will generally be enough, but if you have doubts about your ability to make this fit perfectly, you had better scarf each wall separately, staggering the joints by a foot each. The single scarf should be about twelve times as long as the widest panel of the mast. In a large mast, it is a good idea to v the scarf in each of the four panels, as the shaft of an arrow or billiard cue is made. If you still doubt the accuracy of your carpentry, and fear that the surfaces do not exactly mate, use epoxy for a glue, and seat each seam against a thin gasket of fiberglass mat cut into strips.

CHAPTER 6

# Fundamentals of Rigging: Sail Plans and Sails

RIGGING IS A HIGHLY advanced art which owes its excellent level of development to the invention of wire rope. This single fact is of the greatest importance in helping us to understand the workings of spars and sails.

The most primitive forms of sailing craft are in many ways the most advanced, according to our definition of design which is that the best design is the one offering the simplest possible solution to a given problem. These primitive sailing craft go about their work with the smallest amount of equipment. A single triangular sail set upon a lightweight, unstayed spar was the first rig known in the past and will be the rig, again, of the future. But these early boats were rather small and it was easy for them to carry enough sail to maintain speed in any weather.

As vessels developed and grew in size, the need for clouds of sail to drive them in light weather brought about such intricate designs as the square-rigged clipper ships. Here, where the size of spars far exceeded the natural strength of the available woods, it became necessary to apply a network of rigging. This rigging has always been for just one purpose: to hold the spar in a straight line along its own axis. You see, the end grain of wood is very resistant to compression, so if the mast of a boat can be kept from bending, it acts as a column acts in the foundation of a building, and can carry tremendous loads in proportion to its section. But wood doesn't resist bending nearly as well as it does compression. So, once a spar deflects along its axis, and forms one or more curves, any further compression above these curving parts exaggerates the bend, and





soon the spar will break from deflection loading. The clipper ship, to carry its outsize rig, depended on rope to stay the masts and spars. Rope, varying greatly in strength for any batch, had to be used in great diameters to allow an ample safety margin against breaking. This, in turn, meant extra windage, and to complicate matters further the rope shrank when it grew wet and relaxed and sagged again as it grew dry. By the time wire rope was available, the clipper ship had already built this vicious spiral into its death warrant. Fortunately, wire was being developed in other ways. Use of wire rope in suspension bridges and in aircraft developed it so that tremendous strength can be obtained in small diameters. The manufacturers of aircraft wire, in particular, have produced low-cost, readily available wire which has noncorrosive characteristics and can be fitted with neat, full-strength ends. These are the wires which most concern us, for they are all commonly used on sailboats today.

### Natural Fiber Ropes

The most common of the natural ropes used in boating is manila. This is the traditional rigging material and has an honorable history of achievement. We shall only discuss it briefly, however, for, in the present age of synthetics, manila is nearly obsolete. You see, being organic, that is, made from living fiber, manila is subject to sicknesses of the flesh, such as rot and bacterial attack. It changes its length and diameter greatly with each change in its moisture content and demands constant adjustment and ventilation. When wet, manila becomes stiff and delights in kinking, particularly where it must pass through blocks just out of reach. Although low in initial cost, manila needs constant replacement. There is little reason, therefore, to buy it for today's boat.

Sisal rope has received some publicity, generally in connection with South Sea voyages and Oriental ports. It is a rope made from natural plant fibers, but is a singularly weak material for its diameter and will deteriorate from age or rot more quickly than manila. For this reason it must be stored in great, loose coils to keep it ventilated. It has no advantages over any of the materials used for other types of rope and it has no place in the twentieth century.

Cotton rope can be very decorative, so it is often used for trim work, handholds, dinghy-fender material, and general light work. It seems rather resistant to rot, although it will succumb if conditions are bad. A rope of little strength, cotton ought never be used for anything more serious than decoration.

Some linen ropes are nice to the touch and fairly strong. The Irish linen is among the best. Where you want minimal stretch for a given number of parts, as in sheets or backstay runner tails, linen is an excellent choice. It resists rot and kinking well, looks very "yachty" when new, and is good

for several seasons of hard use. Linen is excellent, too, for the hauling part of wire halliards. You can splice the wire right into the rope and taper it out neatly. Discussion of this method of attachment is in this chapter under the heading "Wire Ropes."

## Synthetic Ropes

Synthetic ropes are as revolutionary, in their way, as wire. They are high strength, rot-free, flexible materials which need no maintenance. While the initial cost is higher than that of natural ropes, the true cost, measured over years of use, is extremely low. These synthetic ropes are elastic, which means they make the very best anchor line possible. They can be stored wet, pick up little weight from water, and are always pleasant to the touch. Moreover, they are very neat in appearance.

The greatest drawback to synthetic ropes is that they are very susceptible to damage from chafing. Of course, this is a relative state of damage, and the synthetic rope that is chafed half through may still be stronger than a natural fiber rope which has not been damaged. Chafing is easily prevented by the use of protective scraps of polyethylene hose which you cut into short lengths and slip over the rope where it passes through the chocks or crosses an abrasive surface. If you wish, you can make a long spiral slit through the wall of polyethylene hose. Then you can force the hose open along the line you have cut and screw it around the rope at any point where it is needed. It is a good idea to keep a number of one-foot lengths of such hose on board the boat, ready for use at any time. The piece of hose which will protect the anchor line should be left unslit and always around the rope, but restrained near the on-board end. Use a piece of hose which fits loosely about the rope but which will jam in the bowed chock. Then, after you have paid out the proper amount of anchor line, you can slide this hose forward and wedge it in place tightly enough so it need not be looked after. If you must pay out additional rope the hose will provide ample clearance so you can do this without dislodging it.

Because synthetic ropes will not swell, it is possible to use the minimum width of block for each line. Not only does this enhance the general appearance of the boat, but it reduces the cost of rigging and keeps the extra weight, windage, and apertures through spars as small as possible.

Of the synthetic ropes, the best known is nylon, which has been in general use since World War II. It can be purchased from war surplus stocks at very reasonable prices, but you must order carefully to be sure you get white rope. Most of the nylon rope used by the military was colored, and although this doesn't seem to affect its characteristics, off-color rope does reduce the resale value of your boat.

Stronger than nylon, but a lot more expensive, is Dacron. In boats to be used for highly competitive racing, where weight and windage, as well



as stretch, are vital considerations, Dacron is an obvious choice. However, it hardly pays to purchase it for ordinary use since nylon is more than adequate. Dacron ropes seem much more susceptible to chafe than nylon, and for applications of abrasive nature, like docking lines, great care should be taken to protect the material from wear. Dacron is rot-proof, very elastic, although less so than nylon, and quite light for its strength.

Polyethylene ropes are coming into common use for dinghy painters, jib sheets and halliards on small craft, and also as water-ski towing lines. Although quite elastic, they are fairly strong, pleasant to handle, and rot-free. Their greatest virtue is their ability to float. For any light towing operation, particularly where the boat will be frequently stopped and started, this is wonderful protection against propeller fouling. By no means should these polyethylene ropes be trusted with critical tasks. At this stage of their development, not enough is known about their life-span or ultimate breakdown characteristics.

## Rope Construction

A rope, unlike a wire or fiber, is a fabric built of many strands. Although we tend to think of all ropes as flexible, this ability to bend varies widely. The most flexible ropes of either wire or nonmetals are used for running rigging, and in the sense with which we shall use this term, we include halliards, sheets, tiller lines, anchor rodes, and any other allied devices. Such ropes are generally made of three or more strands, twisted about one another so as to form a single unit. The strands may be subdivided into many fibers or filaments, but it is the arrangement of the strands themselves which primarily affect the flexibility of the whole.

Now, in a very flexible rope which is made to work around a small pulley, the distortion of the strands seriously affects their strength. The part of the rope nearest to the sheave makes the sharpest turn, while the outside of the rope must cover a greater distance under the same load. To compensate for this variation of load distribution, a cross section of the rope is distorted into an elliptical shape, which again aggravates the problem. For this reason, many flexible ropes of metal or fiber use a core of different hardness from the exterior strands. Bronze tiller ropes, in particular, use a soft core, so you can see that you must be very careful not to run this wire over a sheave smaller than is recommended for it by the manufacturer, or the strands will all get out of line and quickly fatigue or weaken.

Halliard wire, fortunately, has a somewhat simpler problem. Although we will discuss it in more detail in a following section, we must understand its principle here. When you hoist a sail on a wire rope, the load upon this rope is the sum of the weight of the sail, plus the friction of the slides and track, plus any windage, all added to the friction of the halliard sheave,

plus the pull you exert downward. Now, all of this together is just a fraction of the pull the wire is capable of handling, so the distortion of the strands as they pass over the sheave is negligible. By the time the sail is trimmed and drawing, the wire has been secured to its winch, and we can consider that it moves back and forth across the sheave a very small distance only that which its elasticity allows. We can consider the wire to be stationary when it is loaded. This means that distortion is a minor problem and we can make do with a relatively small diameter of sheaves and winches. This same principle applies to jib sheets, as well, for although the load is often rather large, the distortion is small, in this case because the rope is only bending through a smallish angle. This principle, that rope bending through a small distance can be deflected around a short radius, but that rope bending great distances, or doubling back of itself, must go about a generous radius, is most important to you in making up any rigging. Remember this, too, anytime you put an eye ending in a rope of any kind, because, unless you use a thimble to turn the rope back through an easy radius, the eye will soon break down.

We can see that there are some diametrically opposed problems to any rope. First, we want flexibility, but we also want strength, and what we really do is compromise by building up a structure having strands which lie at an angle to the direction of pull. Some omnibus attempts to get strength and flexibility include woven ropes, with strands crossing one another, and cable rope, which simply has more strands. Some day we shall have monofilament synthetic ropes, but meanwhile three-strand nylon is an excellent answer for running rigging worked by hand. See the table in the Appendix giving strengths of organic and synthetic ropes, by diameter and weight.

### Wire Rope

Wire rope is made both stiff and flexible, and when it is stiff, it is very stiff, indeed. We shall talk about this variety first, for it makes up the greatest number of feet of rigging on the average boat. This stiff wire is usually constructed of nineteen strands and these component strands are solid wire, instead of smaller fibers. By presetting the spiral turns into the parts of this rope, it is relieved of any tendency to untwist when strains are put upon it, and it is used mostly for standing rigging where strength is most important. However, to take full advantage of this strength, special fittings are necessary at the ends. The reason for this lies in the stiffness of the rope, which is partly the result of a rolling process through which the metal is put during its manufacture.. This rolling not only shapes the wire but also makes a special arrangement in the geometry of the surface molecules, and any sudden turns, such as would be necessary in splicing, will then cause crystallization and destruction. Consequently, a whole field



of products has opened up for terminal fittings. The best for stainless-steel nineteen strand wire are the swaged terminals which are rolled right to the wire's end and effectively become an integral part of it. The machine which attaches these terminals is a powerful piece of equipment, and there are very few in public use. For this reason, it is wisest to have the ends applied to the wire right at the plant instead of taking the chance that they have been properly attached by the dealer.

There are bronze sockets for the 1 x 19 wire which can be zinc soldered in place. Not only must this be done very carefully but the design of the socket itself is extremely important, because the neck of the attachment must be able to lengthen some as shock loads are put on the wire. The depth of the sockets of these terminals must be at least twelve times the diameter of the wire, and gradually tapered, to be completely successful. There still exists the chance of a poor solder bond, so these are not recommended. If galvanized steel wire is used instead of stainless, the solder bond with zinc can be very good, but the bronze socket in damp salt conditions is a possible electrolysis source.

On very small craft where the total sail area carried by any one mast doesn't greatly exceed two hundred and fifty square feet, it is often economical to use single-strand galvanized-iron fence wire. This superior and inexpensive material will give three or four seasons of use. It is best attached at its ends by first passing it over a galvanized iron thimble, then carefully twisting the remnant end around the standing part so that at least four complete turns are made. Not only must you take care to make these turns close and tight; you also must be gentle so as not to destroy the zinc coating of the wire, or it will soon rust through.

All stiff wires must be coiled in large diameter loops when you are transporting them, and if you can carry them stretched out straight it is still better. Don't forget, when measuring for standing rigging, to allow for the combined lengths of tangs, shackles, chainplates, and three-quarters-open turnbuckles. You can always cut the wire again to make it shorter, but it is cheaper and easier to measure it properly in the first place. By treating the turnbuckles as three quarters open for your measurement, you allow yourself a little leeway in case the wires are cut too short, and you allow yourself a lot of leeway for taking up slack as the wires stretch out to their working length during the first few months of use.

### *Flexible Wires*

The flexible wires are used mostly for running rigging, but in special cases where you wish to splice the ends or use certain terminal fittings, it is perfectly satisfactory to employ such wire in lieu of the stiff variety. The price you will pay for this convenience is that the wire will have less strength for its diameter and weight, it will be more elastic, and is

quite cruel in its chafing action against the sails. The serious racing man will not wish to pay these penalties, but there are places where these wires must be used.

Flexible wires are generally classified as six or seven strand and contain a very flexible core or center-wire surrounded by the six outer strands. The six strand wire, using the nonmetal core, is frequently used as steering cable or halliard material. The softness of this center core allows the wire to distort greatly where it runs over a sheave or fairlead, and this characteristic, which is advantageous at the pulley, is a problem at the ends, for it is impossible to use the rolled-on terminal fittings. Splicing is the simplest, cheapest solution, but there are several excellent mechanical devices which were created for just this sort of wire. A method of clamping the wire end back on itself is called "Nicopress." This employs a hand-operated squeezing tool which forces copper-alloy sleeves so closely into the wire that approximately full strength connections are formed. The user purchases the sleeves and rents the proper size swaging tool. It is a good idea to use two sleeves for each joint, locating them against one another in such a way that one laps the cut end of the wire enough to shield it from snagging on flesh, lines, or sails.

Another excellent, but somewhat more expensive fitting, is the Electroline series. These are bronze terminals which unscrew into three components. The wire is passed through a hole which just clears its diameter, then the strands are splayed open, the soft core is cut away, and a hard bronze wedge is inserted to hold the spread-out strands apart. When the entire fitting is reassembled and tightly screwed together, this wedge exerts great force against the wire strands, anchoring them securely. Electroline fittings come in all standard wire sizes, and with a variety of attachments.

Because the flexible wires are made of many small wires for each strand, they present much more surface area than the 1 x 19 or solid-wire variety. This generous amount of surface makes zinc-soldered end fittings very practical. As in all solder work, the secrets of success include scrupulous cleanliness of all parts to be soldered, the use of a proper flux, and the careful preheating to a temperature such that the solder flows upon contact with the metal rather than from the presence of the heat of the torch. Whatever your heat source, be certain that the flame burns clean, or it will deposit waste products on the metals and contaminate the bonding surfaces. Heat the parts as uniformly as possible, moving the heat source from socket to wire and back again, so they will arrive at the right temperature at about the same time. Use a virgin zinc solder, which contains the smallest amount of dirt and impurities, and you will obtain an excellent bond.



## Splicing

So far we have devoted our attention to ferrous wires using stock-manufactured terminals. The time-tested method of attaching wires, however, is by splicing, and this includes the eye splice, in which the wire is doubled back on itself; the long splice, in which wires are added to one another in a manner that permits them almost to retain their original diameter; and the short splice, in which wire is added to wire but, as the attachment will not be required to pass through a sheave, the diameter is unimportant. A description of splicing is given in the Appendix.

A highly specialized splice is the wire to rope splice. This is a variation of the long splice and is a common method of making up halliards which can be hand-hauled until the load becomes great, then put on a winch, where the wire continues to do the work. A word description of this splice is extremely difficult to give. Leave this to the professionals.

Splicing is about the only satisfactory way to terminate bronze wire. Although good solder joints are possible, the heat burns up the soft core, and the wire distorts very badly in such areas. Bronze wire is so much more flexible than the ferrous wires that it is the best suited for constant bending, and this is why it is safe for steering cables, centerboard pennants, and inaccessible remote controls. Some very good flat clamps have been especially developed for bronze steering wires, and permit easy adjustment against stretch, while being entirely dependable when set. Those made of galvanized iron seem best; they generate the most friction against the wire.

While it is true that any splice will reduce the strength obtainable from a wire by as much as thirty per cent, still, the remaining strength is entirely dependable. This is in contrast to swaged or soldered connections which are improperly done. A splice announces its correctness at once when you see it by its uniform pattern, but other terminations may hide their shortcomings until the chips are down.

## Rigging Fittings on the Spars

Although early methods of attaching rigging to the spars included wrap-around splices, eye bolts, and collars, these have all become obsolete with the invention of the tang. Tangs are straps of sheet metal analogous to chainplates on the hull, and they distribute the loading of the wire over a generous amount of spar area. The secrets of tang design and attachment are these: remember that the strength of the tang must equal the strength of the wire, and that it must fasten against the spar in such a way as to carry this full load. A common and ridiculous sight is a wire stay, capable of lifting fifteen tons, attached to the spar with a single nail.

It seems best to attach the tangs for the shrouds by running a single

bolt through the spar and the tangs on either side, then staggering a number of screws along each tang so that they don't perforate the mast in a line like the separations in a block of postage stamps.

It also is not unusual to see a mast wrapped with a sheet of chafing gear through which dozens of little nails make a dotted line about the spar that almost screams: "Break along this line." When it breaks, it will certainly be along that line.

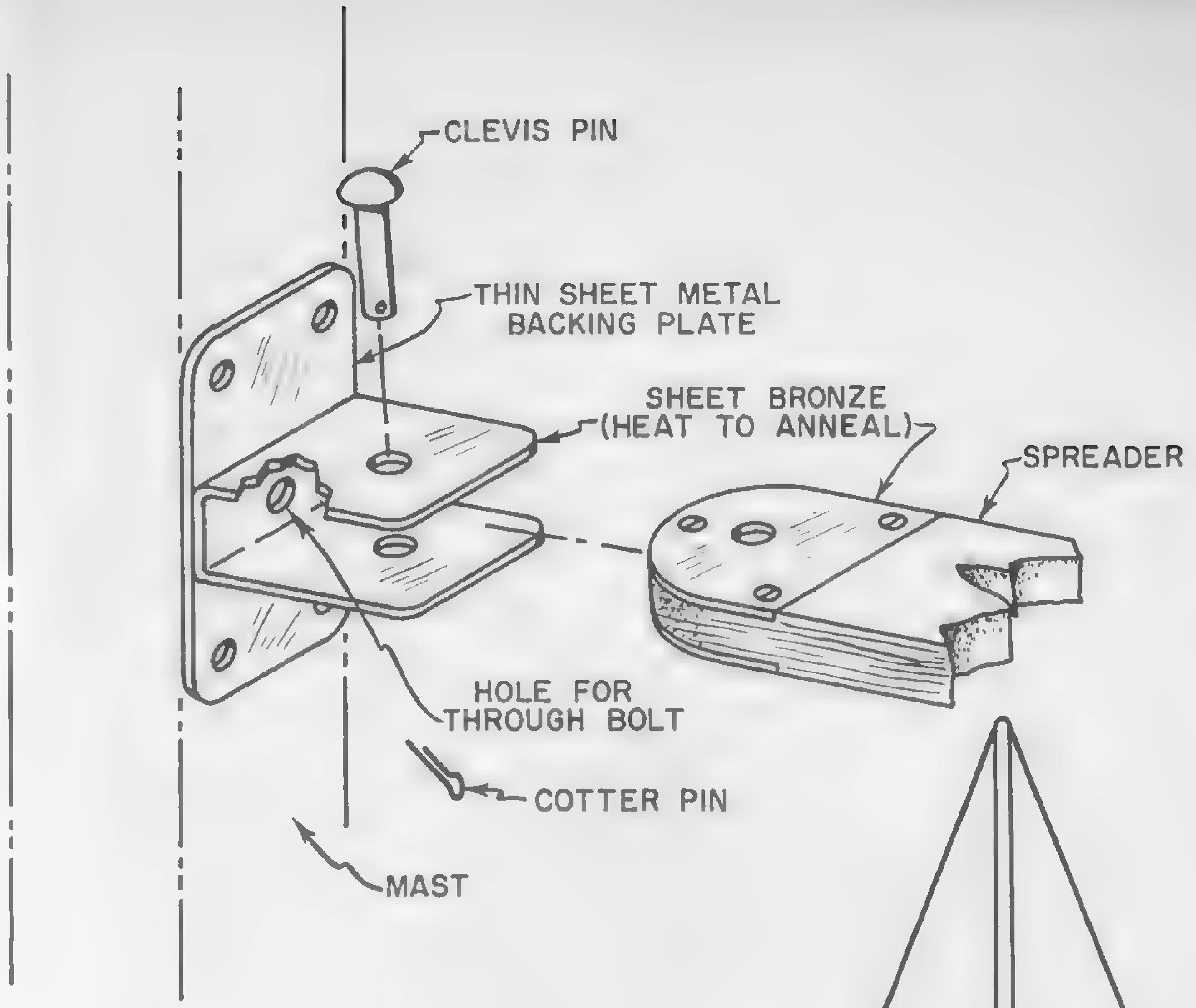
### *Spreaders and Attachments*

The upper shrouds are the wires which support the top of the mast and keep it from sagging off to leeward. Now, because the top of the mast is usually a great distance from the deck, the upper shrouds would run almost parallel to it and give it no support if it were not for the spreaders. The spreaders are the struts which thrust out from the port and starboard sides of the mast and bear against the upper shrouds, so they will deflect through a greater angle and be able to give maximum support to the head of the mast. Since they are struts under compression, and are generally very slim in proportion to the spar, it is important that they be given every opportunity to go about their work properly. This means, first, that they should have no tendency to deflect. To insure that the load is always normal to the axis of the spreader, you must cock up the ends so that the angles between the spreader and the wire above and below it are equal. This is the most important single thing you can do to provide for proper lateral support of your masthead.

Next, because the mast will sway and deflect fore and aft, and because dockside damage and lapping jibs exert force against the spreaders via the upper shrouds, the spreaders should be free to swing, in a horizontal plane. This is easily accomplished by an attachment as shown in Plate 1-6 here. Such an arrangement not only allows the spreaders to take normal, natural lines against the forces of the shrouds, but protects the spreaders from damage during storage and stepping of the spars. There is no danger of the windward spreader folding, even though the joint is free to swing through 180°, because of the lower end of the shroud being anchored outboard and in line with the spreader tip.

The tip, or outboard end of the spreader, should provide a broad notched face, lined with a strip of brass or copper against which the wire sets. To prevent the wire falling out of the notch on the leeward side, a second strip of metal should retain it. See Plate 2-6. It is good practice to wrap the tips with plastic tape to keep them from chafing against the sails.

Spreaders should be airfoil in shape to reduce drag, and some typical sections through a well-designed spreader are shown. See Plate 3-6. In maintenance, it is important to keep the upper surface of the spreaders



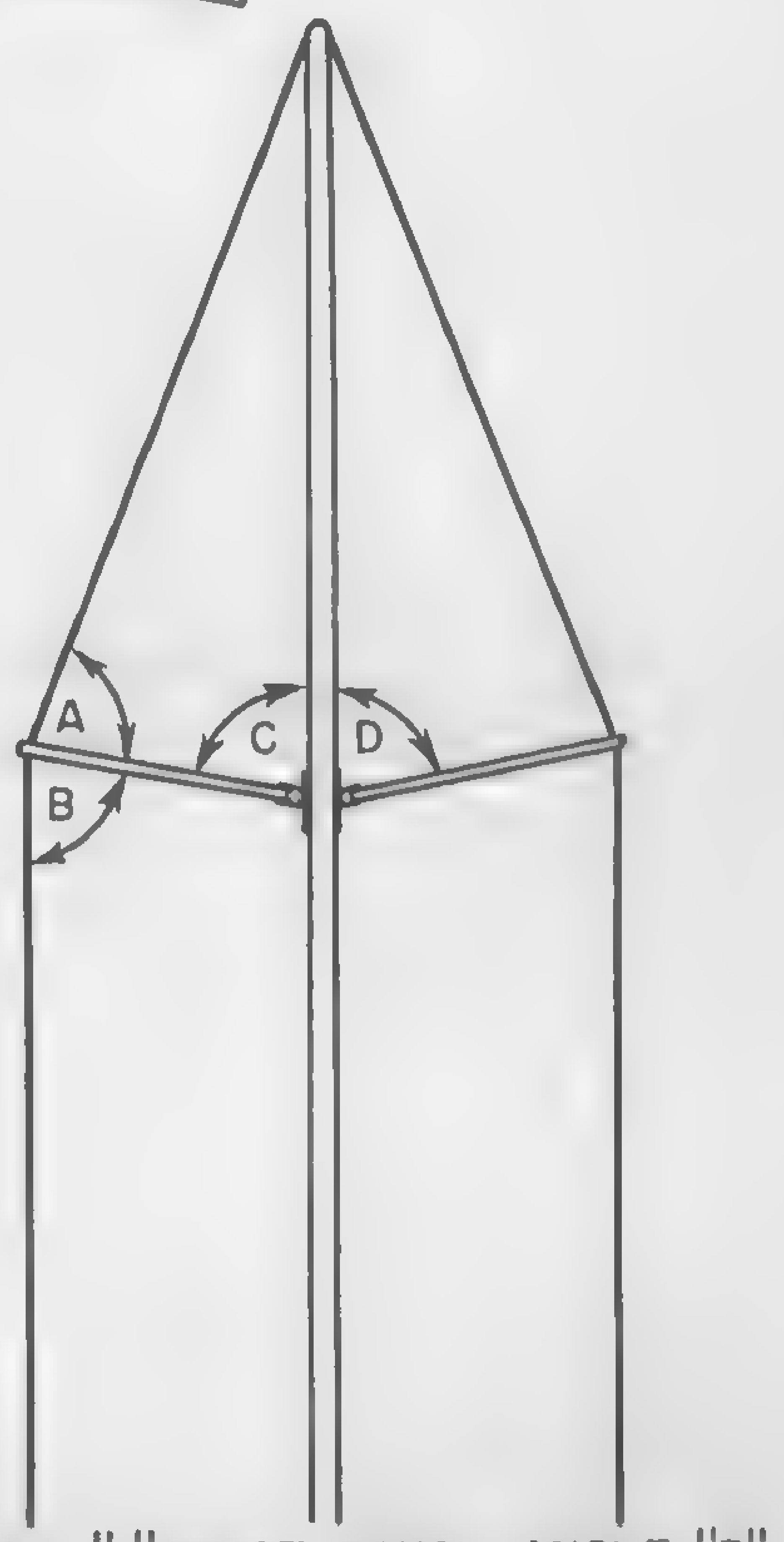




Plate 1-6. Mast and spreader fittings showing free-moving spreader articulation. At right, diagram showing spreaders attached to mast and proper angles of spreaders and wire rigging.

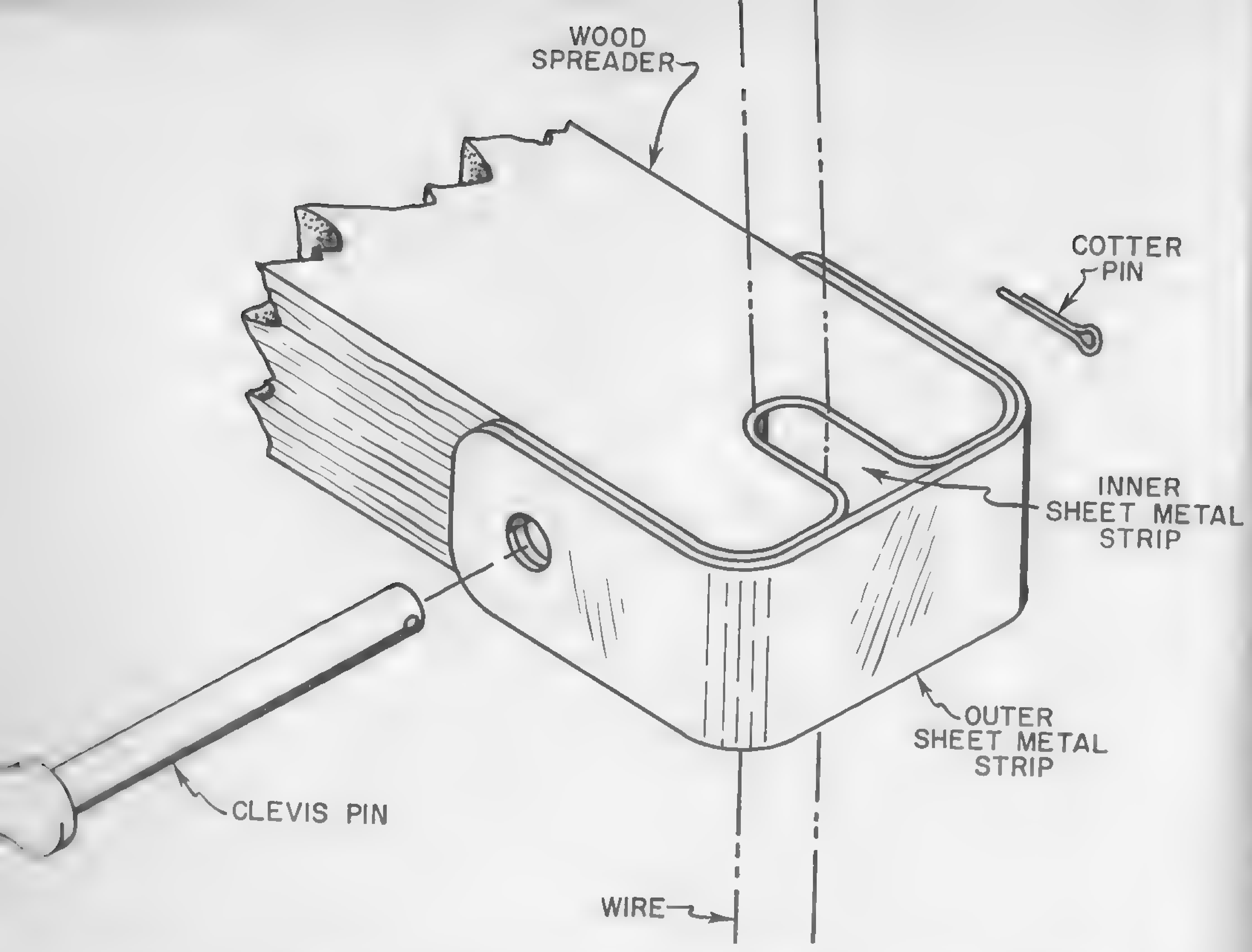



Plate 2-6. Illustration of sheet-metal assembly attached to end of wooden spreader. It cushions the wood from the wire, prevents the wire from splitting the spreader, and retains the wire in the spreader notch.

Plate 3-6. Illustrations showing airfoil sections through a spreader. Notice how the sections rotate their slope axes as they approach the spreader tip.



well protected with a finish, or they will check and weather. The most efficient surface is fiberglass-reinforced plastic, pigmented white to reduce heat transmission. This is also impervious to the acid and alkali attacks of bird droppings, which can eat away the wood.

**Masthead Fittings**

Masthead fittings can be made very simply when one takes advantage of the bolt which is used to retain and pivot the main halliard sheave. If this bolt is designed to a high strength material like silicon bronze or Monel, it can be fabricated as a large diameter tube, which keeps its weight low but provides a large bearing surface against the spar. For the shrouds, a U strap of sheet phosphor bronze or sheet Monel is carried right over the mast from left to right and pinned in place with the halliard-sheave bolt. The ends continue beyond the bolt, then are bent out a bit to act as tangs. This method distributes the compression loads of both halliard and shrouds, sharing them between the sheave bolt and the top of the mast. In large craft—boats which have mainsails in excess of four hundred square feet—it is useful to cap one end of the tubular sheave bolt and fit a grease-gun attachment to the other end for easy lubrication. In any case, the synthetic sheaves are the lightest and the best and can be used for very large sail areas.

Fore and aft staying at the masthead of a spar is slightly more involved. If the boat is to carry a spinnaker, it is best to allow the pulley block for the spinnaker halliard freedom enough to swing exactly in line with the sail's pull. Here, as always, the best way is the most simple. A Vail, or wrap-around strap securely bolted to the spar, carrying one or two links of light chain between it and the block, will do the trick.

Masthead backstays bring up the problem of chafe; they wear on the leech of the mainsail and often block the headboard from coming right up to the sheave. You will frequently see great masthead bridges extending aft to ameliorate this condition. The use of these bridges is a bad practice. They provide an out-of-line fulcrum for the backstay so that the mast may deflect more and even break. It is better to carry the masthead a little higher than the top of the sail and make the backstay clear in this way. However, in boats with headsails which do not reach the masthead, the problem reverts to running backstays, where the sail area is large, and none at all in boats of the size we shall generally consider.

You see, the function of the running backstay is to work against the jibstay or forestay and so keep the luff of that forward sail as straight as possible. When a spinnaker is carried, the backstay becomes a preventer, keeping the mast from deflecting forward. If you are racing, this will be more important to you than if you're cruising or day sailing, but the fundamental law of backstays is that they should attempt to equal the

distance behind the spar that the forward stay reaches ahead of it. And if you can even exceed this distance, it makes a far straighter mast and luff. Set the running backstay as far outboard as you can, at the same time you run it aft, and it will help to work against leeward deflection.

### Rigging Attachments at the Hull

Although it is easy to make neat, strong rigging attachments aloft, where we are very conscious of weight and windage, it is shocking to see some of the huge fittings that appear at deck level. Remember that the load upon a wire is the same at either end. If a simple sheet-metal tang will hold the spar aloft, there is little reason to use a high-steel forging down below. The principal warning is against fastening all the chainplates on one side to one plank, because they will gradually pull up the sheer-line over a few years of time and ruin the boat. Long chainplates are a blessing to wooden boats; they spread their loading over many separate planks and frames.

The stemhead fitting ought to be quite strong because it will be subjected to much abuse in docking and boat handling. A silicon- or manganese-bronze casting is readily made from a simple plywood pattern, and this can be shaped to cap the stemhead and run down the stem to protect it for several feet. See Plate 8-5.

In fiberglass-reinforced plastic boats of good design and construction, the hull material is quite as strong as any load from the rigging. Here it is satisfactory to fit chainplates with several large-diameter, wide-spaced bolts right through the hull; but take care to set them against soft lead washers before you tighten them or they may crystallize the plastic. The larger the diameter and the further apart the holes, the happier will be the setup. A good method of attachment is to make chainplates of large sheets of metal with big holes punched through—holes of nearly one inch diameter. These plates are laid up right into the hull of the boat during building and are neat, leakproof, and entirely strong.

### Pins and Turnbuckles

Although there are a variety of good bronze and stainless-steel turnbuckles on the market, the galvanized-iron ones are still the best and safest. Bronze and stainless steel will crystallize in rather short periods of time, and give little or no warning to the sailor, who can't subject them to laboratory tests. The hot dipped, galvanized-iron turnbuckles will take plenty of abuse and, although you will have to renew them every five years or so, you will probably never have to renew your mast because of them.

Clevis pins, which are the large pins passing through the jaws of



linking assemblies, are quite satisfactory in galvanized iron, but because the terminal fittings of the shrouds will wear the protecting zinc away and expose the iron, these may have to be replaced every year or two.

Cotter pins are dangerous to sails, skin, and lines, and should all be properly taped to prevent their snagging. Taping them further assures their permanent attention to their work. There is no single thing so unnerving to the crew as to hear a "plink" on deck, and to look down and find a cotter pin lying at the rail.

## SETTING UP THE RIG

While the more subtle adjustments of rigging will be discussed in the chapter "Tuning the Boat," the basic rules of setting up the rig are important to us here.

The greatest single mistake is to set the shrouds too tight. This puts a greatly exaggerated strain on the mast, which has quite enough work to do already. First trim the boat so she is level port and starboard, and check this level against the horizon or with a bubble. Then hang a plumb bob from the highest halliard, so that the bob is down at deck level. Now align the spar left and right with the shrouds, adjusting just the uppers or just the lowers. Set up the wire until it shows no slack. Now, using the track as a sighting line, with your eye near deck level, adjust the rest of the shrouds in the same manner.

When this is done, set the after lower shrouds up tight against the jibstay, making it stand very hard. If there is a double headsail rig, you will do this with the maintop backstay first, then with the after lower shrouds. With a single masthead jib, just the maintop backstay will be set in this way. The forward lower shrouds should be tightened only to remove all slack from them.

Now the upper shrouds can be set up, and these should be tuned rather hard; because of their greater length they will stretch more than the other wires. In no case do you want to make violin strings of your rigging in small boats.

If your jibstay doesn't reach the masthead, and if you have a set of jumper stays from the lower shrouds to the masthead, you will have to set these up first, while the mast is on the ground. This is simply because you will have to go aloft to make any changes after the mast has been put in place. These jumper stays should be well tightened. Set them up so that they just barely bend the top of the mast forward when no other wires have been set up. The pull of the backstay will bring the mast straight again after the boat is rigged and the vectors of force delivered to the jibstay will keep it taut and perfectly straight.

### Rake

Rake is the angle to which a mast is inclined in a fore and aft direction. Historically, it derives from the days when the halliards were also used as cargo hoists. By slanting the mast aft so that the halliards, when detached, would drop vertically through the cargo hatches, it was possible to use the same hoisting arrangement for loading the vessel as for raising the sails. Hundreds of years of tradition in this usage made it customary to rake masts aft. When yachts came into vogue they were generally cargo vessels which had been converted to pleasure use. So, in the evolution of yachts, the reason behind the tradition was lost but the practice of raking masts was carried on. Through the ages there have been a great number of experiments with rake and, certainly, different vessels respond in different ways to changes in this inclination of the spar. You see, when a mast is slanted further forward or aft, the entire center of effort of the sail plan is shifted and the relationship of the net center of sail area to the center of lateral resistance of the boat is called "lead." The fore and aft location and extent of lead is a strong factor in influencing both the steering qualities of the vessel and the amount of leeway it makes when close hauled on the wind.

There are one thousand theories concerning rake, and some boats use very complicated mechanical devices for changing rake in infinitely small increments. While a certain amount of after rake helps the jibstay to stand when the jib is carried inside a spinnaker, any further refinements are questionable. You will just have to play around with it until your boat goes best and steers easiest. You will find that every one of the complicated theories is no more than nonsense when you undertake to translate the words into reality, but there does indeed seem to be a real correlation between rake and performance. In most of the fastest modern sailboats, the mast stands absolutely straight when the boat is at rest.

### Blocks and Winches

Winches for halliards and jib sheets are standard equipment on most small boats today. The best ones available in the United States are made by the South Coast Company at Newport Beach, California. This firm also manufactures blocks which are surfaced with a synthetic that makes them noiseless and nondestructive to the decks and brightwork. One winch in particular, made by South Coast, is designed for handling sheets on the Star Class boats. Although intended only for this special task, these winches have been used successfully on several large ocean-racing yachts for halliard and light sail work. They are entirely satisfactory and very inexpensive.

The synthetic pulleys of nylon and other plastics include the excellent line of Tufblox products from England. These are obtainable in the States, and make the lightest, strongest units of all. In this series are included excellent jam-cleats and snubbing winches.



### Bitts and Cleats

Bitts and cleats are the fittings to which mooring lines, anchor rodes, and running riggings are attached. The single or paired vertical postlike structures are the bitts. The most common types in use aboard pleasure boats are those with a single vertical post through which a horizontal pin is inserted so that a spliced eye or loose turns of rope cannot jump or slide free of the post.

Bitts and sampson posts can be made from sand-core castings of bronze or from fiberclass-covered wood. Soon they will be available in synthetic materials that will be light and trouble free. If you make your own of glass-covered wood, choose a wood like fir instead of oak, or you will have trouble getting proper bonding. After the wood has been coated and cured, check for pinholes where fresh water might enter and cause rot. Always run the pin in a sampson post fore and aft so that it can't trip you or foul your gear when you're moving about on deck.

Cleats are the tie-down fittings which lie with their long axis parallel to the direction in which the rope is leading. If there is any single piece of advice about cleats it is that they cannot be made too strong nor can they be too firmly fastened to their hold-down surface. Wherever it is possible, the cleats should be bolted to the deck or spar and set in a bedding compound to prevent water from entering the holes through which they are bolted and causing rot, rust, or decay.

Metal cleats are obsolete, heavy, and costly. You will find cleats of reinforced plastic to be cheap, light, waterproof, and well designed. They are satisfactory anywhere any cleat would be used.

### Sail Plans and Sails

The five basic rigs found in small boats today are the cat, sloop, yawl, ketch, and schooner. Although several other sail plans persist in large vessels, they do not concern us here and are mostly of historical interest.

The cat rig is the simple one-sail arrangement on a single spar. Although it is generally associated with dinghies, it is sometimes used on boats as large as forty feet overall, including the famous Cape Cod catboats and the Bahama "dinghies." The geometry of the sail may be triangular, quadrilateral, or even a variety of arcuate shapes, some particularly interesting curve patterns being used in the fishing rafts of Brazil. Except for very small craft, however, the cat rig is rather awkward to use. You see, to get sufficient sail area, the spar must be quite far forward in the

boat. This makes steering difficult under some conditions. You remember when we spoke of rake we defined the term "lead" as the fore or aft distance of the center of sail effort in relation to the center of the boat's lateral resistance. We noted then that the extent of this lead and its location influenced the steering characteristics of the boat. In the catboat, the lead is so great and so far forward that, like a weather vane, the boat's principal desire in life is to head directly into the wind and it tries to accomplish this at every opportunity. The cat rig also puts the sail, spars, and halliards where you cannot easily tend them when handling sail. However, such an arrangement keeps the mast from interfering with cabin space, so in certain cases this is reason enough for the rig.

Sloops are the commonest racers and cruisers among small boats. The arrangement consists of a single mast with a mainsail hoisted on the after edge, and one or more headsails arranged forward. The tendency today is to use a single headsail, or jib, often set right up to the masthead. This is extremely simple and efficient. The mast is well back in the boat where it can be adequately supported by rigging, and where the crew can handle sails from a secure location. It is possible to make sloops very easy to steer, and they can be trimmed so that they will steer themselves part of the time. This is the rig which best suits the average small boat, for, besides the reasons already mentioned, the sloop is easy to handle under the mainsail alone, which is a blessing in tight quarters or bad weather.

Occasionally, one hears a sloop referred to as a "cutter." The cutter has long been extinct and, although there are some survivors which are almost museum pieces, the family strain has given rise to the sloop, which bears little resemblance to its forebear. The cutter was a single-masted vessel with a housing, or portable, topmast, a bowsprit and jibboom which could be pulled inboard to shorten it, and a loose-footed mainsail laced to a gaff, above which a topsail was set flying. A cutter also carried three headsails, a working staysail, a working jib and a flying jib, so called because it did not set on any sort of stay or other support at its leading edge, and the fore and aft position of its tack could be varied in order to balance out the steering characteristics of the boat. You can see from this definition why it is extinct.

The yawl is really just a sloop which has added a mizzenmast, that spar much smaller than the mainmast and set way aft in the boat. It enables one to set quite an expanse of extra sail, when reaching or running before the wind. Moreover, in heavy weather, you can drop the mainsail and go under jib or "jigger" (mizzen sail) which makes for a very snug combination. Recently, the Cruising Club of America racing rules have given the yawl a very good chance in racing, for such a rig gets a handicap allowance that favors it strongly. Steps have just been taken to re-equate this allowance, but the yawl still is a necessity for serious long-



distance racing under the CCA rule. The mizzenmast on a yawl, by definition, is stepped aft of the point of intersection of the stern of the boat and the waterline, or, in some cases, aft of the rudderpost at waterline.

The ketch is a variety of yawl in which the mizzenmast is stepped forward of the points mentioned for the yawl. The advantages of the two rigs are about the same, except that the yawl, having a larger mainsail and headsail area, proportionately, is a faster rig for the same area. The ketch has one additional advantage and disadvantage. Because the mizzenmast is further forward, the mizzen sail sometimes is easier to reef and furl. However, the mast generally is stepped in or through the cockpit, in a ketch, which takes up a lot of room and often affects the engine installation and the line of the propeller shaft.

The schooner rig sometimes looks like a ketch rig turned end for end: the large mainmast is well aft in the boat and the small foremast is up toward the bow. The schooner reached its height of glory more than thirty years ago and is now not often seen. For pleasure craft, there is no particular advantage to the schooner rig. Area for area it is not fast. It takes up a lot of room in the boat, for the spars enter the living area at two points. The rig is complicated, and often hard to steer, and sets very little sail area before the wind, unless special light-weather sails are carried. The most successful use of the schooner rig has been in a fine yacht named *Niña,* where the foremast is small, the mainmast is far forward, and the rig has been lightly referred to as a "two-masted sloop."

## Sails

There have been a number of complicated theories expounding the aerodynamics of sails, and some of these try to show that sailboats work to windward because of a low pressure, or partial vacuum, on the leeward side. While this low-pressure area frequently exists, anyone familiar with boats and airplanes, who also understands some of the elements of physics, will realize that it has nothing to do with the problem. A close-hauled sailboat moves forward because her sails have deflected the wind which hit them and have driven that wind aft. Sir Isaac Newton took a lot of trouble to formulate his law of action and reaction, which explains to us that the mass of air driven aft, multiplied by the speed at which it is moving, exerts a force. This force moves the boat ahead. The only complicating factor is the angle at which this blast of air leaves the sails, but the vacuum has no influence on this either. That famous vacuum is simply a coincidence resulting from the fact that a lot more air hits the sail at high speed on the windward side than on the lee side, because the sail has got in the way of the wind that wanted to go to leeward.

Now, with this in mind, we can examine the shapes and surface characteristics of sails and their specific purposes. Since we spent the last

paragraph working to windward, we shall first discuss sails intended for that task.

The everyday sails used on your boat are called the working sails, and you have noticed that they very effectively carry your boat on any heading the wind permits. In order to be so useful in general, they will have had to sacrifice specialized qualities in particular, and the usual compromise is designed so that the boat will go to windward somewhat better than she will run free. This means that the sails set in rather gentle curves and are not at all baggy. They also are usually higher than they are wide, a term of this relationship being "aspect ratio." This formidable mouthful is simply the number of times the hoist of a sail is greater than the foot. For example, a sail twenty-one feet high and seven feet wide has a three to one aspect ratio. This is about the maximum limit of this proportion, and such a sail is very hard to make up so that it will have a perfect shape. However, if properly made, a sail of these proportions is extremely efficient for sailing to windward.

To understand why, let us look again at Newton's law of action and reaction. We said that the boat is driven forward with a force equal to the mass multiplied by the acceleration of the air leaving the sail, when we're working to windward. We also mentioned that the angle this air leaves the sail has important effects on forward drive. Now, when a sail has a low aspect ratio like one to one (e.g., twenty feet high and twenty feet long) the leech, or trailing edge of that sail, makes quite an angle. In our example, the angle is forty-five degrees, so a great deal of our deflected wind will shoot up instead of straight back, which seriously decreases its effectiveness. But there is another detriment to its efficiency: sailcloth, no matter how smooth, has texture and friction. The greater the distance the wind must travel across this material, the more the friction slows it down, diminishing its force. A tall, narrow sail only has to move the wind back for a short distance, keeping the friction loss to a minimum. And, because that sail is tall, it still affects a great amount of wind. It even gains a further bonus. The higher we move from the surface of the water, the greater the wind velocity, for the sea itself slows the wind by friction at its surface. This, in turn, makes the relative direction of the wind freer, so that, as the sail sags off a little, due to its height, the wind is more nearly right for it.

Unfortunately, for this efficiency to windward, the tall, narrow sail pays a severe penalty when running before the wind. Under this opposite set of conditions, the wind pushes the boat forward, not with its deflected and increased force, but with its own original force from which is subtracted the velocity of the boat. You see, if we realize that the boat is running away from the action of the wind, the resulting force still must equal the mass of the wind multiplied by its acceleration, and this accelera-



tion has been seriously decreased. Under these circumstances, to get maximum speed from the boat, we must increase the mass of the wind acting on the sail, and the only way to do this is by increasing the area. Since there are practical limits to mast height, we add a little to the foot of the mainsail in the original design of the boat, and then use a variety of light-weight, huge sails forward of the mast, such as spinnakers, ballooners, and so forth.

If you are aerodynamically inclined, it will interest you to watch certain birds. The gull, albatross, and longtail have extremely high aspect ratio wings. They are gliders, using very little muscle action to sustain them in flight. Their wings attack the wind in the same way our boat tacks to windward. The robin and sparrow have short, wide wings, which beat the wind rapidly, and they stay aloft by moving masses of air in short, fast strokes.

It may seem a long step from birds' wings to sailmaking, but the cutting of a proper suit of sails is an art, and no formulae can be given to ensure that you will do a perfect job. Instead, you must master the principles behind and the reasons for the various shapes of sails, then translate your intentions into cloth.

### *Breaking in Sails*

New sails made of such organic materials as cotton or flax require a period of careful stretching before they take on their proper shape. This is not only a period in which the fabric and stitching settle down, but the rope along the luff and foot must reach its intended length. The technique with a triangular, or leg o' mutton, sail is to pull it hand taut on the boom, just enough to flake the rope out so it doesn't hang in sags. Then hoist the sail, battens in place, putting just enough tension on the halliard or downhaul to make the luff stand straight. Always get the sail up quickly, taking the strain on the boom lift until the halliard is secured. Start sailing as soon as possible, steering the boat on a reaching course, in gentle winds. The weather should be dry, and you should keep the boat out sailing half an hour or so before putting a little extra tension on things. Never try to stretch a new sail taut. If you can avoid it, never reef a sail while it's new or drive it hard. (Keen racing folk will use old or badly cut sails for cruising, keeping their best sails just for competition.) The moment there is danger of rain or heavy spray, slack the outhaul and halliard a trifle on boats carrying natural-fiber sails. These may shrink, and the sail itself will contract, putting a terrific strain on everything and stretching badly out of shape. On gaff-rigged sails, where the peak outhaul is beyond your reach, you will be wise to lower the sail and slack the outhaul aloft, as well as the boom outhaul.

New, organic sails usually contain a starch which helped the cotton

or flax staple keep its shape in weaving. This will wash down the sail in the first rain or two, concentrating itself along the foot toward the tack of the sail. This also holds moisture, and sometimes attracts more water, so mildew will usually accumulate in this area first. There are two remedies: first, you can wash out the sail thoroughly with fresh water, a long, troublesome job; second, you can saturate the sail with mildew-preventer. Barfair is the trade name of an excellent product. The sail can be painted, sprayed, or dipped in such a compound, which will greatly contribute to its mildew resistance. Whether you treat your sails or not, and regardless of the preparation, you should always dry natural-fiber sails before furling or storing them for any time. Mildew grows best in damp, stale air. Even sail covers, which overlie furled sails on their spars, contribute to such an atmosphere, and in small boats there is no reason for not removing the sails and drying them properly between trips.

Synthetic sails include nylon, rayon, and Dacron, the British equivalent of which is called "terylene." Nylon is an excellent material for light sails where stretch and elasticity are desired, such as in spinnakers, mizzen staysails, ballooners, and spinnaker staysails. However, for sails which will be carried to windward, Dacron is the finest material. Synthetic sails made of Dacron require no breaking in, are not damaged by mildew, and are singularly strong and tough. Because of the smooth texture of the fabric, skin friction is very low, and the sail lets the wind slip along it faster. This synthetic is very airtight, too, so no force is lost through leakage. Sails made of this fabric are light, set well in gentle winds, and stow in small sail bags.

There are only two considerations of which you must not lose sight with Dacron sails: the toughness of the material makes the seam stitching lie on the surface, where it is easily chafed through, and the presence of Dacron and salt air seems to injure brass and stainless steel, so you must coat your luff wires with plastic and use galvanized-iron thimbles and cringles. However, these conditions are easily met and the extra long life of these sails makes them excellent buys. Wire rope is available with plastic coating applied at the factory. One fine variety, called "Pacote," is available from South Coast Hardware, Newport Beach, California.

### Sail Repairing

The commonest failure of sails is the breakdown of seam stitching. This results from chafe, age, salt dehydration of the threads, or sun aging. Some of these sicknesses enter the threads of the sailcloth itself. The repair for seam deterioration is restitching. If you have a sewing machine at home, you can do the job in luxury. It is no more involved than simply following the original seam juncture and sewing over it with cotton thread.



If you are going to do hand stitching on board, you will want a palm, a kind of huge thimble which lies across your hand, and a pair of pliers with very fine serrations on the jaws. The palm will push the needle most of the way through the material and the pliers will get it through the remaining distance. Use the smallest needle which will carry your weight of thread and always try to resew through the original holes in the cloth. The perforations of additional needlework only weaken the material. You should beware the triangular-shaped needle usually included in sail-repair kits. It is brutal to sail fabric in all except the largest, heaviest rigs and will often tear old cloth which would have otherwise held up well enough for another season.

When repairing a tear in the fabric itself, it is imperative that you use a patch. Some are available which you can press on with a hot iron, and they are entirely satisfactory if the sailcloth is dry and free from salt. Moisture and salt saturation interfere with the adhesive bond, so that under these conditions such patches don't last. A stitched patch is completely satisfactory. Use preshrunk fabric, preferably the same material as the sail so the stretching and shrinking won't distort the cloth, and roll the edges of the material under in such a way that the patch can't unravel. There is no particular stitch that is better than any other but, if you have a sewing machine which does zigzag work, it makes for a very shipshape job. When hand sewing, use tiny stitches. Remember that the only part of the stitch which carries the load is the part passing through the sail and the patch. The rest of the stitch simply keeps the thread in place. Cotton thread, particularly the waxed variety, is good to use on synthetic sails, where it seems to chafe less quickly than nylon or Dacron.

Roping sails is a simple task but requires strong hands. Sew through the seam along the edge of the sail, whipping the thread around the rope about half its diameter, then stitching right through the rope and back to the sail. If you want the job to look professional, you will work each stitch around one strand of the rope, each side. Since the purpose of the rope is to take some of the load from the luff and foot of the sail, it is perfectly good practice to attach the rope to the sail on just one side of the luff and foot seam. If you have a powerful sewing machine, this makes the work go very quickly. Use a synthetic rope for synthetic sails, and a rope which has been lightly tarred for cotton and flax. Sails which set on wire stays, or are set flying without support, like ballooners and spinnakers, should have wire ropes. These are best covered with plastic so they won't hurt the cloth from rust or chafe.

Remember that wire rope will not stretch or shrink noticeably, but that other ropes must be fitted to allow for change in length. Synthetic ropes stretch quite a bit and are best sewn to the sail with some slight

initial tension. Try to stretch such rope between two secure points and put a strain on it somewhat similar to that you would apply in ordinary sail setting. Natural-fiber rope will take quite a lot of stretch from which it never recovers except in the shrinking reaction to water, which is a transient set of conditions. Therefore you can sew this kind of rope in place with no particular allowance. It will reach its permanent size as the sail is stretched.

The only rope ordinarily used on a headsail is a short bit of reinforcing line which is stitched to the fabric for a foot or so each side of the clew. Such a rope must be gradually tapered to its ends. This technique is also used to finish off the bolt rope on a mainsail, where the rope will be carried over the headboard of the sail and around the clew, to stretch for about twelve inches at either end of the leech. The method of achieving this taper is to unlay each of the three strands and cut out part of the fibers of each at several points, then retwist the strands and stitch the rope. The ends of nylon and Dacron ropes can be fused to keep them from unraveling. This is accomplished either by holding the ends in a flame for just a moment, or by dipping the tips in resin and letting them cure.

For the luff of a headsail, wire is universally used today. Remember that stainless steel wire is susceptible to attack from salt water, and that this attack is accentuated by some materials, so be careful not to damage the plastic coating of the wire when you sew. The normal method of affixing wire luff ropes to headsails is by first stitching whippings through the sailcloth and tightly around the luff wire, then sewing a tape over the luff of the sail to envelop the wire. It is possible, however, to fold the sail around the wire directly and stitch it. The drawback here is that, as the sail wears, there is no way to correct it except by a follow-up taping job.

Old sails sometimes tear along the reef-point grommets, which are the metal rings used to reinforce the cloth. Grommets should always be attached through a patch, even in new sails, and the reef points ought always be located through a sail seam. Grommets are available from marine hardware dealers, but you must also purchase, for a dollar or two, an iron punch and die to secure them. Good practice to follow for installing reef-point grommets is to set them through the sail, at the seams, before stitching on the reinforcing patches; then, after the patches have been affixed, sew back and forth through the reef-point hole so as to line it with stitching like a button hole in clothing. This distributes the pull of each reef point over a greater area of material. This pull can be very great and is most concentrated near the clew of the reefed sail. Because of this, you should make the reef outhaul cringle attach through a long, generous patch; otherwise, the sail will soon stretch seriously at that point.



### *Snaps, Slides and Headboards*

Sail slides will need constant maintenance if they are attached by marlin or sail twine because the cord will quickly chafe away. This is particularly true at the headboard and clew outhaul parts of sails, where the strain is greater than at other areas. If you are handy with soldering equipment, cut woven-copper antenna wire into lengths of three or four inches, then flux and tin the ends. You can whip the slide to the sail, using the wire as you would use cord, and knot the ends so you can solder them fast with a single touch of the iron. For this sort of work, an instant-heat electric soldering gun is best; with it, you can work accurately without danger to the sail.

Sail snaps generally freeze after a few seasons because an accumulation of corrosion builds tightly around the pistons. It is best to remove the snaps from the sail, to avoid any chance of injuring it, then flush the inside of each snap with a corrosion solvent. The aerosol solvents are good and many of them will also lubricate the sail snap against further corrosion. Be careful to snap out and dry off all excess chemical or you will stain your sails.

Headboards usually wear through the sail after years of use and must be built back into their position. This is done by laminating several thicknesses of fabric around and over the existing cloth and metal, but carrying the new material an inch or so further into the working area of the sail. Dacron is the best material for this, regardless of the type of fabric from which the sail is made. Back up the area along the headboard where sail slides will attach, using a patch or two of elkskin, which is obtainable from your sail maker. This will reduce the wear that the sail slides induce through their wire lashings.

### *Recutting Old Sails*

The first reason for recutting old sails is to give them new life and shape. After many seasons of use, a sail will stretch until it sets very flat and doesn't develop much drive in light winds. Often the fabric and seams are still sound, but the shape must be restored or the sail will only be valuable in heavy winds. The recutting operation is one which can only be learned through practice but, if the sail in question is particularly bad for anything less than a gale, you may as well experiment with it.

The curve, or airfoil, shape of a sail is put in on the cutting floor. Generally, the seams are all stitched as parallels and the sail is a rather flat object before its final outline is created. This only applies to fore and aft sails for general use, and is not true in the case of reaching and running sails, where the panels of cloth in the sail are tapered. But, in a typical mainsail or jib, the curvature is put in by the cutting along the edges.

In a sail which has a straight line measurement of twenty feet from tack to head, you might curve the edge of the luff forward about three inches. This curve is established by springing a batten made from some rather stiff wood. You mark the mid-point of the luff, measure out your three inches, and drive a tack, bending the batten around this point and bringing its two ends in to the head and tack positions on the sailcloth. Don't forget to allow an extra inch for your hemming of the cloth. A typical curve to the foot of such a sail might be an inch or two, but the greatest bulge will come well forward of the mid-point on the foot. Try it about one third of the distance from tack to clew back of the tack. The roach, which is the name of the area enclosed in an arc extended from the leech, can be about four inches in a sail of these dimensions. You will need two or more battens to make this roach keep its shape, and they should be at least eighteen inches long. The roach rarely needs recutting.

Battens, in general, should be smallest near the top of the sail, rather long near the middle, and somewhat smaller again toward the foot. They should be thin sections of stiff wood, like ash, tapered at their forward ends so they are more flexible there and will bend with the curve of the sail. The best batten pockets are called lock sleeve pockets and the illustration (Plate 4-6) shows how they are made.

There are two leech conditions which can be remedied by recutting. The first is the case of the leech which stretches in a tight line from head to clew of the sail, accentuating the bagginess of the fabric ahead of it, and making the sail extremely inefficient. This condition drives the deflected wind back to windward and may give the boat a terrific weather helm. If you think about this problem, you will be able to trace the tightness of the leech to too much curvature in the foot or luff of the sail, near the head and clew. You can understand that this is just a problem in geometry and the cure is to recut these perimeters so they have flatter curves. Try recutting just the foot of the sail at first, and only straighten it a little bit—sometimes taking half an inch from the greatest part of the bulge will be sufficient. Don't attempt to recut the luff until you have experimented with the foot, and never try to cure this condition by recutting the leech itself.

The opposite problem to the tight leech is the loose, floppy leech which falls over to leeward in calm weather and shakes the entire sail in heavy winds. Since this problem is opposite to the tight leech, the cure is exactly the reverse. Here you want more curve in the foot and, possibly, the luff of the sail. Again, experiment first with the foot, and cut a little more curve in it, trying to keep the amount of increase about one-half inch at the clew end. This measurement, entirely arbitrary, is just to guard you against over-cutting the first time you experiment with sail altering. If you can't control the leech from the foot of the sail, try lengthening the battens and batten pockets. This is not usually adequate alone; only in combination.

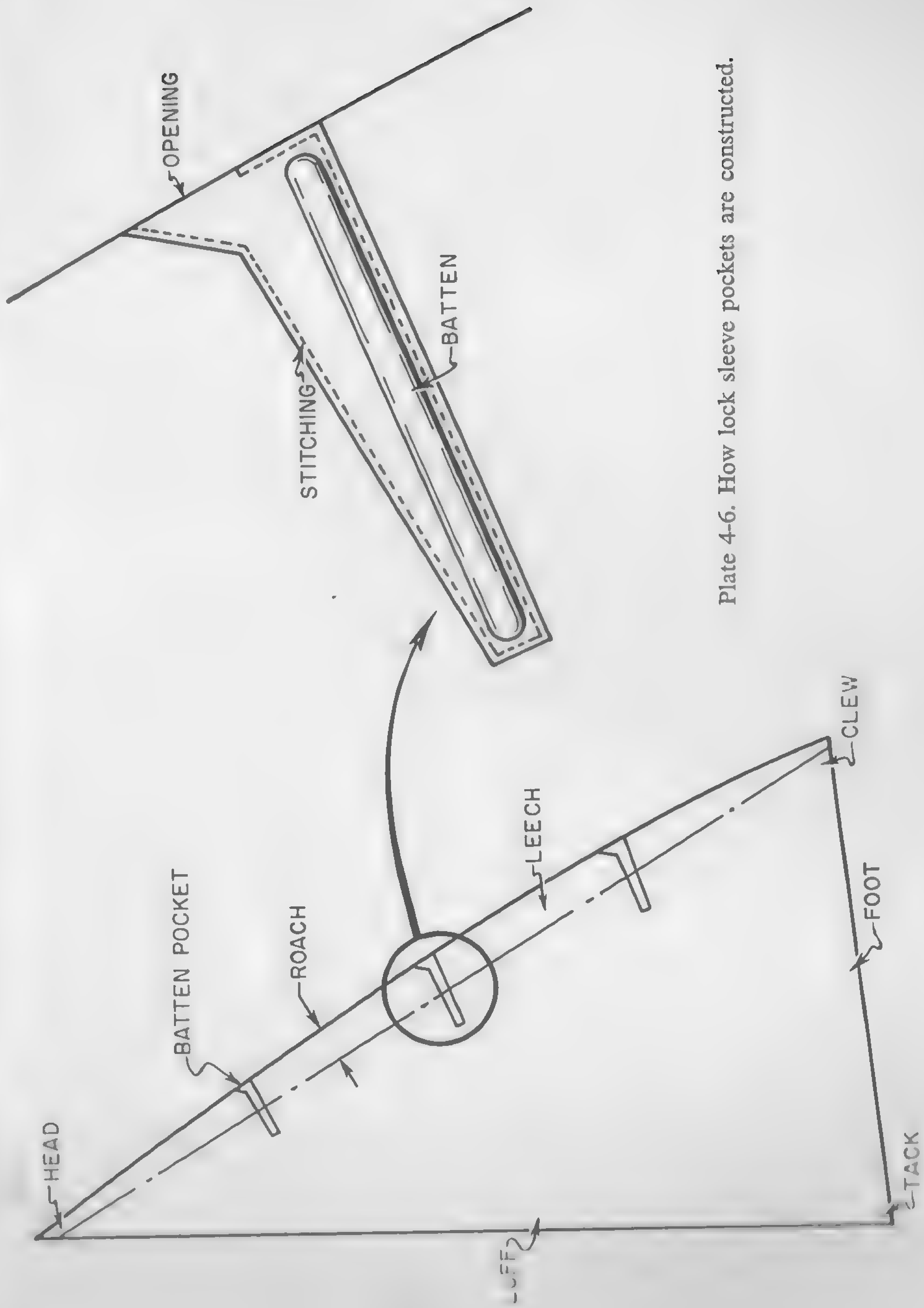



Plate 4-6. How lock sleeve pockets are constructed.

Another reason for recutting old sails is to make them into more useful equipment. For example, you may have an opportunity to buy a used sail which can be easily converted into a storm sail for your own boat or into a piece of cruising canvas which saves your racing suit some wear and tear. Second-hand sails are always available. They are frequently advertised in the boating magazines and there is one shipyard which has made itself a sail trading center. This is Rodstrom's Shipyard, Pilot Street, City Island, New York. They publish a list of available used sails, giving you measurements, material, condition, and price. Sometimes you can obtain a new sail which was just off measurement for racing or was left over as unclaimed from the sailmaker.

### Storm Sails

Storm sails rate special attention because they are often misunderstood but very useful devices. The greatest misconception about such sails is that, because of their name, they must be very strong and heavy. However, because storm sails are a good bit smaller than working sails, they can usually be of the same weight material as the latter. This also means that a sail that has outlived its racing usefulness may be easily converted to heavy-weather use.

The proportions of a storm sail should be determined by the fact that it will set loose footed, must ride high enough above the boom to clear the mainsail when it is furled, and not bear its load against the most poorly stayed part of the mast. To understand this last condition, you must realize that the storm mainsail will often gybe and slat violently. For this reason, it is proper to design it so that the luff doesn't greatly exceed the height of a set of shroud attachments. A good example of such a sail might have the head ride a foot or so above the intersection of the lower shrouds, have the tack ride about one foot above the main boom gooseneck, and let its clew attach to a bridle, so the sail is free to gybe as much as it likes. The illustrations show some typical proportions. See Plate 5-6, Photo 6-1.

If you carry a storm jib as well as a storm mainsail, you should cut the foot up very high so that a wave coming over the bow can't drive into the sail. Storm jibs ought to be set well inboard, so, if you have a boat with a bowsprit and double headsail arrangement, use the forestay for attaching this sail.

Storm sails are made without roach or battens. The seams usually are parallel to the leech and are triple stitched. The best material for such sails is Dacron, for storm sails are stored for years between use, and then are generally put away wet, after the weather has cleared. Because of this infrequency of use, it is a good idea to consider some substitutes for storm gear without the bother and sail-spoiling hazards of reefing. For example,


Plate 5-6. Simple masthead rig for modern 27′ sloop with bowsprit. Dotted lines show storm sail Genoa jib outlines. Note height of head of storm mainsail above spreader, not carried more than about ¼ distance of unstayed portion of spar above spreader.

in small sailboats which have a dinghy, the sail from the dink may be a very useful size to steady the boat in rough seas. This can be particularly true when the problem involves a little vessel running under power in the troughs of large waves. It may also be an entirely adequate sail in severe thundersquall conditions. Another alternative rig involves keeping a set of spare sail slides. In weather when you want to save your mainsail, you can snap the luff of your working jib to the sail track slides. The jib is then hoisted on the mast track and the sheet run well aft to give it a fair lead. Such a sail will usually give you excellent control of your boat, with reasonable speed and weatherliness and good steering characteristics.

### Light Sails

Light sails include any canvas you set running before the wind, as well as the sails suited particularly to gentle wind conditions. These sails are made out of the lightest material available, in order that they may be easily lifted into shape by vagrant winds and have so little inertia that they don't violently slat this wind out of themselves when the boat gyrates. You must keep their fittings light, too, and this is usually overlooked by amateur sailmakers. The result is that the sails droop sadly in really faint wind, which is just the time you need them most. Use stainless-steel cringles and attach the sheets with bowline knots, instead of heavy bronze snaphooks on heavy rope. One trick with light sails is to make them red or orange. This heats the air in the sail where some of it remains trapped, forcing that air to rise and give the sail draught.

There aren't many light sails an amateur can make, their anatomy being rather complex. However, it is possible to turn out a decent reaching jib, mizzen staysail, or spinnaker staysail, simply by cutting the three sides of the triangle in deep arcs. You will have to turn to professional labor, however, to cut a spinnaker or balloon sail, for these are quite involved, and the gollwobblers carried by schooners are tough work even for specialists.

### Sheeting Arrangements

Sheet leads for headsails are best located when you can actually hoist the sail in a calm. Then you should trim it to the close-hauled position which puts it in its proper relation to the shrouds. Large jibs with a lot of overlap are rarely sheeted in between the shrouds and the mast, so it is best to be suspicious of any such arrangement. The sail may set properly in this slot when it isn't curved by wind, but be badly misshapen in actual working conditions. Since most jibs are miter cut today, with the seam from the clew running right across to the luff, you can use this seam as a general guide to locate the sheet block. The sheet will usually drop at an angle about ten degrees steeper than the angle of the miter seam.

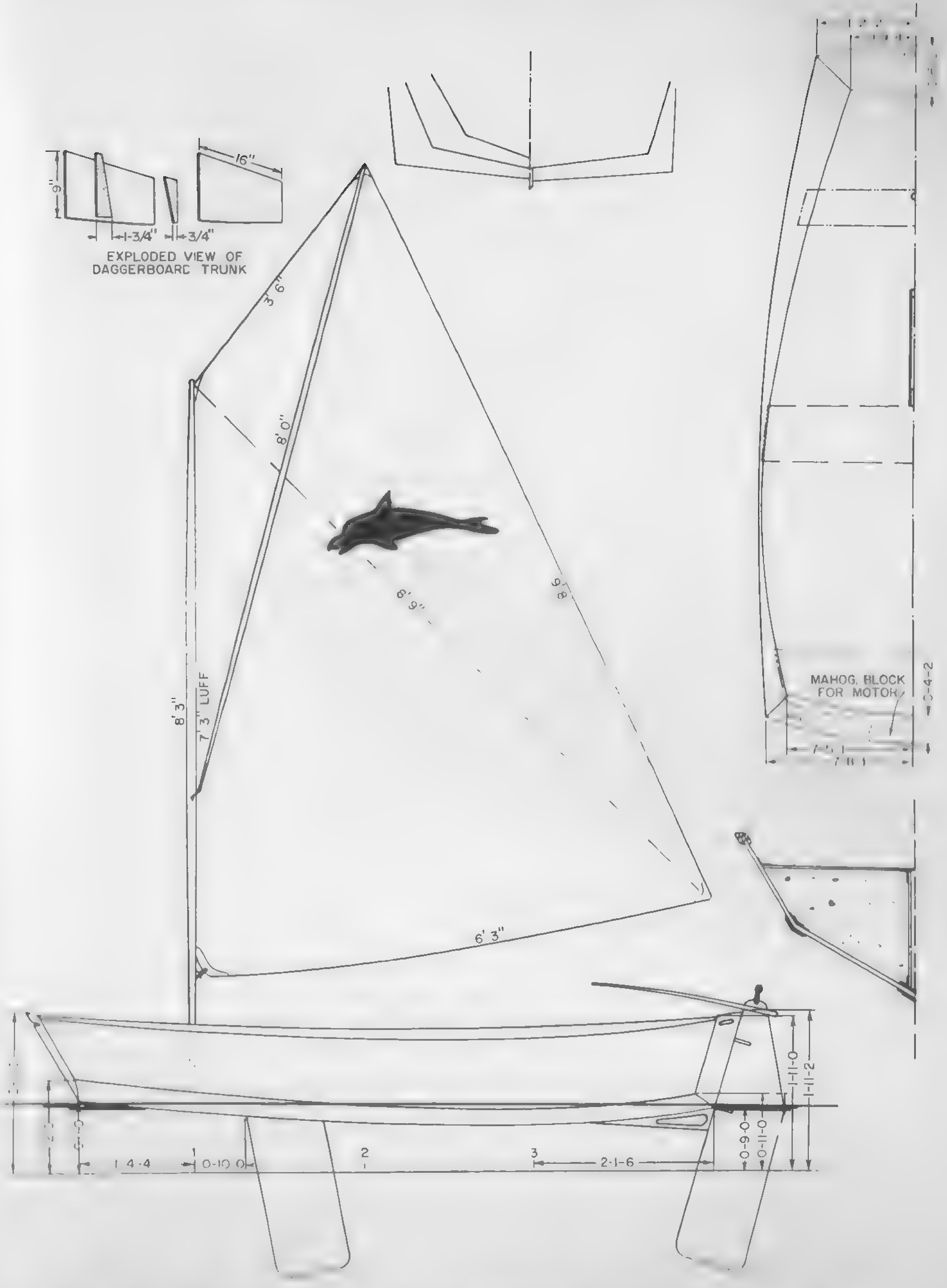



Plate 6-6. This is an 8′ overall flat-sheet fiberglass pram dinghy, which is sufficiently simple so that fleets of them have been built by children in community projects. Drawing shows cantilevered mast and sprit rig, each component of which is short enough to stow inside the boat. Note there is no boom. Sail is rolled up on mast; no halliard, nor rigging, except sheet.

Because it is hard to locate the proper sheet-block position except within fixed limits, it is customary to mount the block on a heavy slide which can be fixed at any position along a length of track running at the rail of the boat. In small boats, ordinary sail track will be adequate for this job.

You can judge the size of the track by the area of the jib. Compare it with the area of your mainsail and see what size track that utilizes. Generally, seven-eighths-inch bronze sail track is fine for boats up to about thirty feet overall; you can use five-eighths-inch track on boats up to about twenty-five feet.

No sheet should ever lead from the centerline of the vessel. This is particularly true of mainsail sheets because the area of such a sail, plus its retention to a boom, will twist it badly along its trailing edge. In a small sail, like the mizzen of a yawl, this is not as noticeable. There are basically two ways to sheet these sails from positions athwart the centerline. On small boats, one frequently finds the sheet led from separate blocks on either side of the cockpit. On larger boats, where deck room is available, a strong piece of track, or a metal traveler, is employed. In this latter arrangement, it is necessary to lead the running end of the sheet to a centerline position forward or aft of the traveler, so the sheet has no tendency to hold the sail off to one side.

A good arrangement for sheeting storm trysails, or headsails attached to clubs, is the gun-tackle method. It consists of a rope made fast to the deck at one end, carried up through a pulleyblock on the sail or boom, led down through a second block on deck, then to a cleat or winch. This allows the sail to be self-tending in gybing or tacking and, in the case of the storm trysail, it enables you to lead the sheet over the main boom without incurring chafe.

**Getting the Best Sails**

The cost of synthetic materials has made good sails of Dacron and nylon rather prohibitive in the past. Now these prices are coming down and, because the materials are so far superior to anything else, it makes sense to buy them at any price. They will outlive natural-fiber sails many times over. It was also said, at an early stage of synthetic sailmaking, that perfect fitting sails could not be cut except from cotton. This is a viewpoint entirely without foundation nowadays. It still is important to pick your sailmaker. The difference in price between a top quality sailmaker and an ordinary one is probably not fifteen per cent of the total cost of the sails. The chances are better that you will have good sails when you use the best manufacturer and the resale value of your boat will be substantially higher. This same resale criterion applies as well to synthetic sails. It is hard to market a boat which is fitted out with any other sort. See Plates 6-6, 7-6, 8-6, 9-6, 10-6.

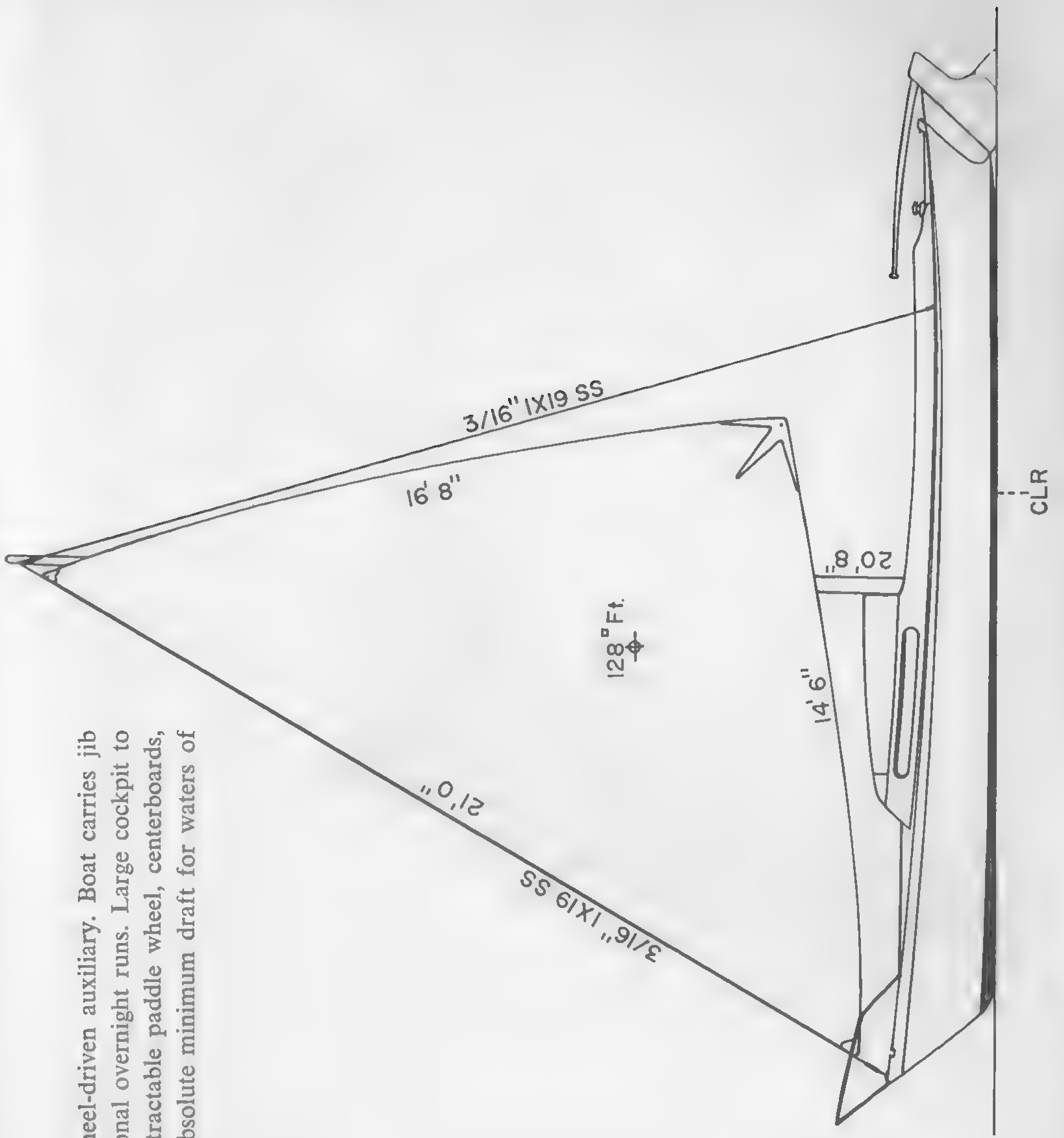
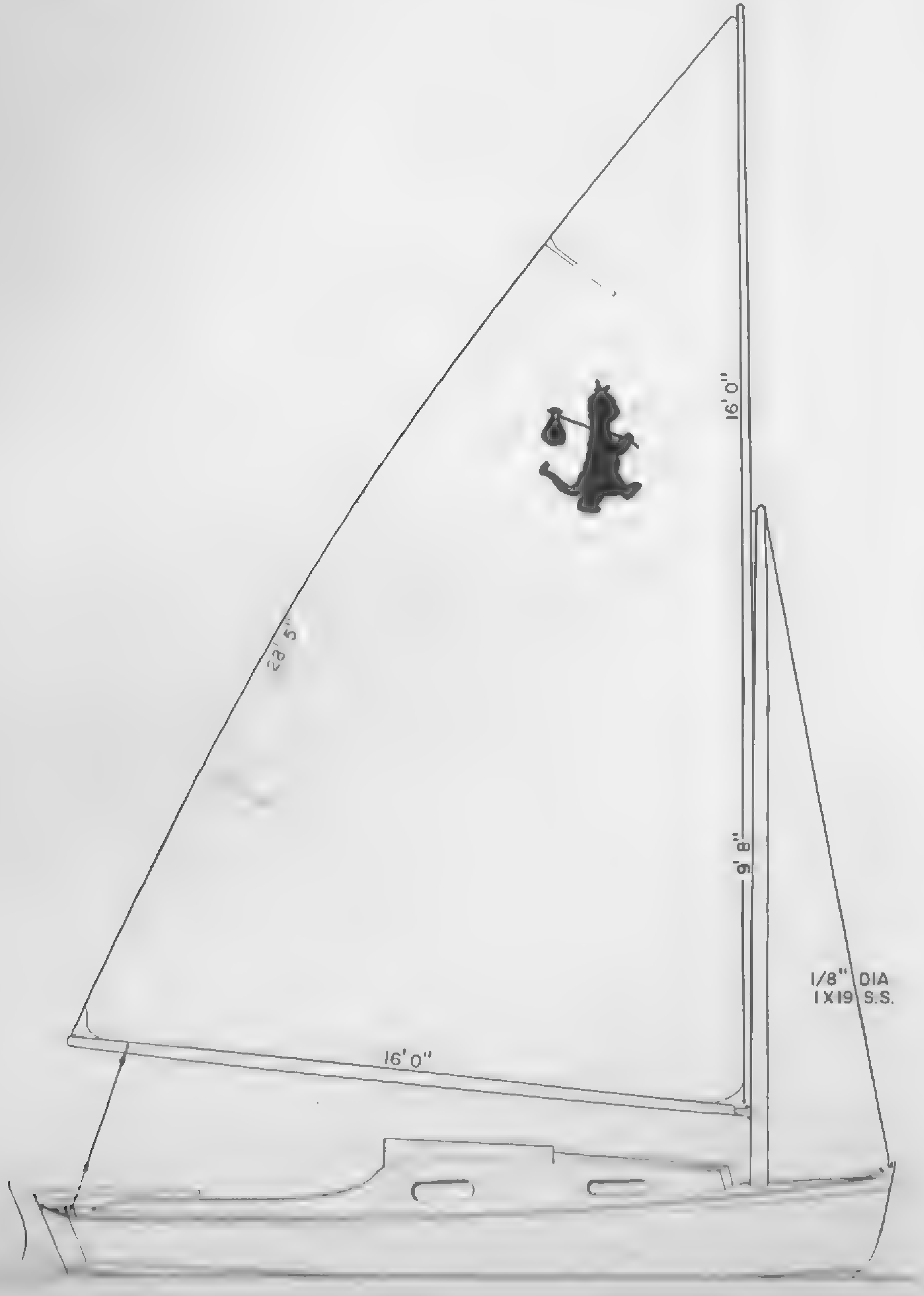



Plate 7-6. This is a 20' overall paddle-wheel-driven auxiliary. Boat carries jib only. Intended for day sailing and occasional overnight runs. Large cockpit to accommodate fishing or sailing party. Retractable paddle wheel, centerboards, and folding rudder intended to provide absolute minimum draft for waters of Florida and Bahamas.

Plate 8-6. Another illustration of the 20′ overall Travel-Cat, showing sliding gunter rig on modern catboat. Mast is cantilevered but gunter halliard leads forward to stem and acts as headstay as well as halliard. Note mast saddle on which gunter slides. See detail drawing of same in plate for "Construction" Chapter.



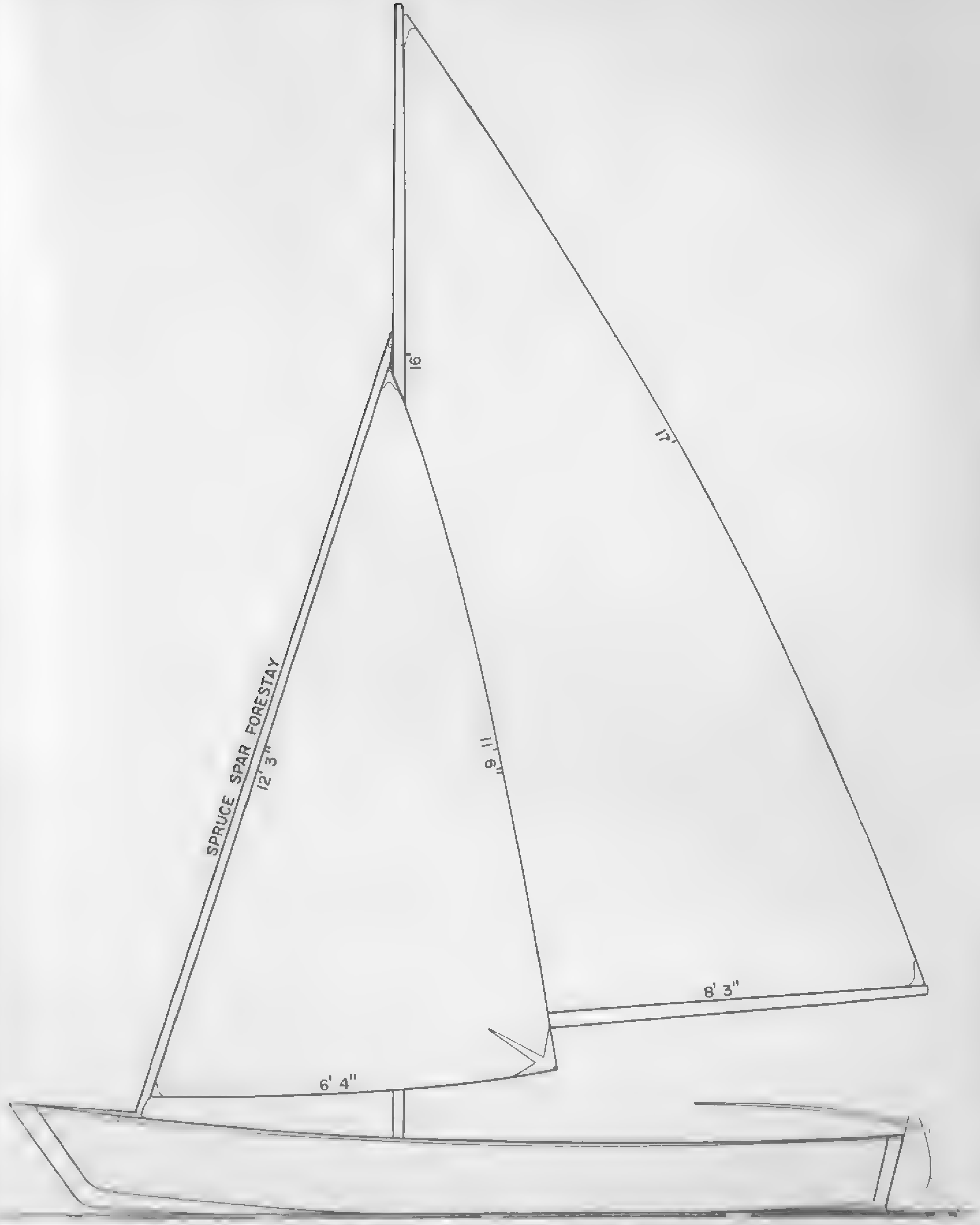




Plate 9-6. A sloop-rigged pram, 14′ overall, shows cantilevered sloop rig. Spar forestay and mast are not rigged except for halliards. Spar forestay and mast are both slotted to carry luff rope of sail. Forestay rotates to make clear airflow into jib.

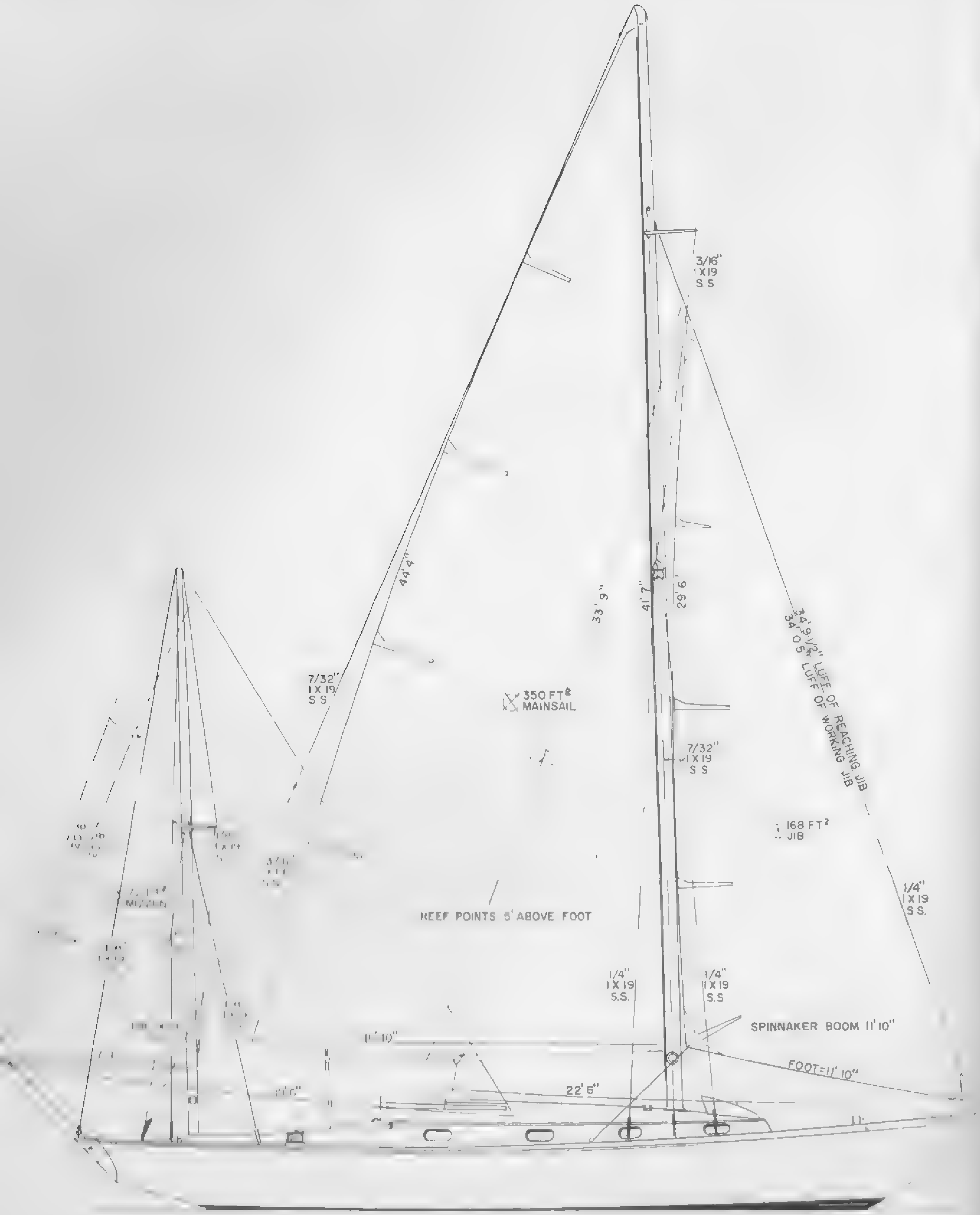



Plate 10-6. Simple, modern yawl rig. Shows jumper–strut arrangements on mainmast and mizzenmast, proportional heights for spreaders, relative location of stay and shroud arrangements, wire types and sizes. Note upper shrouds do not reach to masthead, as jumper stays carry load above struts.

CHAPTER 7

# Interiors and Cabin Plans

THE INTERIOR LAYOUT of a boat is such a personal thing that it is often difficult for a designer to know when he is impressing his will on his client. There are, however, some basic principles of construction and layout which are important to observe. It is important, too, before making changes in a cabin, to spend a full season sailing and living with its arrangement before you alter it. Remember that we human beings are very flexible animals. It costs us nothing and takes little time for us to adjust ourselves to various ways of life. Unless you are a thoroughly seasoned boatman, you may be tempted to try some arrangement of accommodations which is not only impractical at sea but is a definite liability to the resale value of your boat.

## CONSTRUCTION OF INTERIORS

Before making physical alterations of any sort in the interior construction of your boat, it is important that you study the part you intend to change until you are certain that you understand all its functions. Many apparently innocent objects in the cabin have been arranged by the designer or builder so that they serve a variety of purposes. Some of these extra functions may not be at once apparent. This is also true of certain critical structural parts which stem from the hull of the vessel and lead dual lives where they can be used to supplement interior layout. One example of this might be a locker wall, which was designed also to serve as a structural bulkhead. The face of a berth may also function as a longeron,

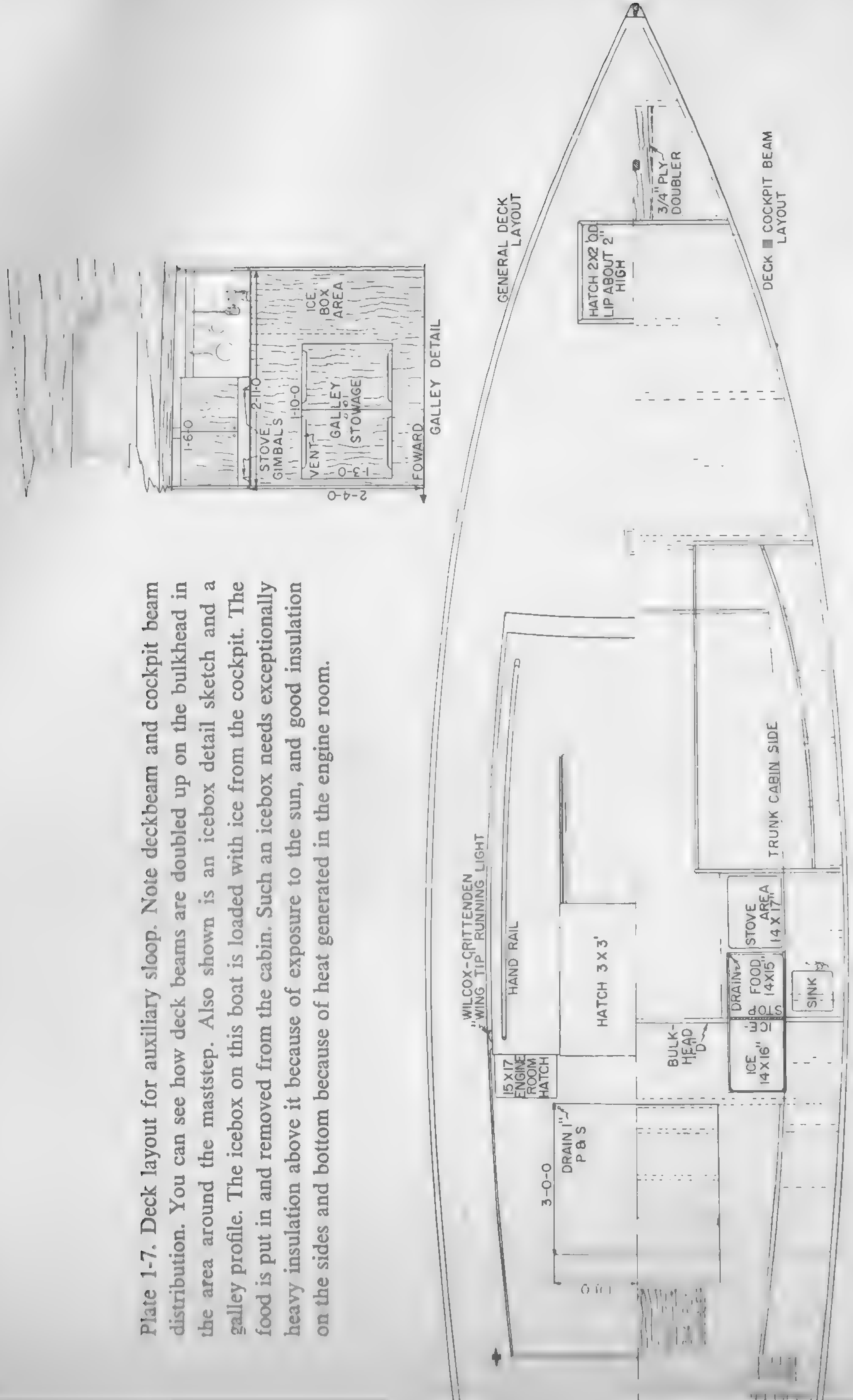



Plate 1-7. Deck layout for auxiliary sloop. Note deckbeam and cockpit beam distribution. You can see how deck beams are doubled up on the bulkhead in the area around the maststep. Also shown is an icebox detail sketch and a galley profile. The icebox on this boat is loaded with ice from the cockpit. The food is put in and removed from the cabin. Such an icebox needs exceptionally heavy insulation above it because of exposure to the sun, and good insulation on the sides and bottom because of heat generated in the engine room.



giving fore and aft structural strength. That long bookshelf in the forepeak is probably permanently laminated to one of the stringers which are secured to the frames of the boat to help them resist wringing.

A good quick check which will help you to determine the importance of these different structures can often be based on symmetry. If parts are duplicated left and right or fore and aft, they almost always are structural in nature. But they need not be duplicated as mirror images of one another in order for them to be symmetrical structures. For example, even if that long bookshelf in the forepeak only occurs on one side of the boat, you should look in the area on the opposite side of the shelf to see if some other structural member is not present. A bookshelf on one side might be supplemented by a locker or storage bin on the opposite side. When in doubt, and always before removing a structural member, discuss the problem with a knowledgeable boatbuilder or experienced designer before you make any change. Remember that, by sawing through a deck beam to locate a hatch where no hatch had been before, you can cause the collapse of the entire boat. That deck beam, you see, might be the one which helps most to keep the deck in line. See Plates 1-7, 2-7.

It is particularly important, when you permanently remove any structure attached to the skin of the hull, that you plug the holes from the old fastenings at once. If any of those fastenings did extra duty by helping to secure the object you removed, you may have to change the fastening altogether. For example, in a boat which had its engine in the cabin, you may want to take out the old engine bed and relocate it under the cockpit sole. It is not uncommon for the bolts which hold down the engine bed to run right through the frame or floor timbers and, sometimes, the planking. If you take out such a bolt when you remove the bed, and merely glue a dowel in place to fill the hole, you may seriously reduce the strength-giving qualities of an important skeletal section of your boat.

The most dangerous things to remove from your boat are partitions because they are almost always structural bulkheads. One of the more famous cases of bulkhead removal in recent years concerns a man who cut a wider passage through the partition between the cabin and the forepeak of his sailboat, not knowing that the mast, which was stepped on deck, pressed down against a step which just bridged the original passageway. The tensile load of the wire rigging thrust the mast and its step right through the boat, somewhat in the same manner that an arrow is shot from a bow.

In open boats, where slat floor boards are fastened down to the frames, they may serve a secondary purpose. Such floor boards may also be acting as stringers. For this reason, you must be very careful not to cut through them to gain access to the bilge unless you first build reinforcements for the remaining slats which will have to carry the load.

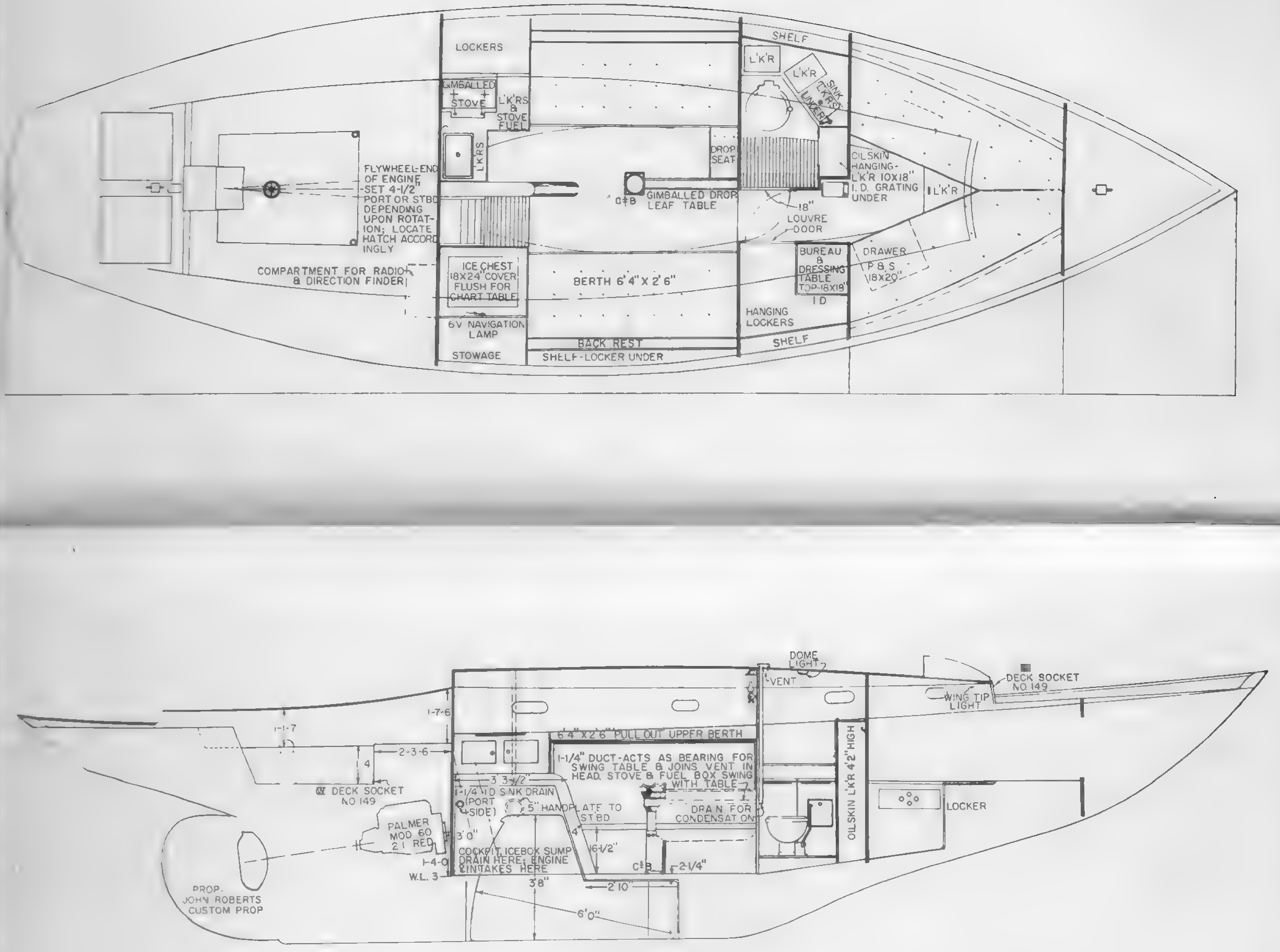



Plate 2-7. The 37′ overall centerboard yawl. Note modern, fiberglass construction makes frame-free interior. Full headroom throughout cabin area. Icebox top kept smooth to double as chart table. Note gimballed cabin table. Charcoal fireplace on end is gimballed with table (see detail sheet in "Construction" chapter) and ballasts it. The stovepipe acts as table hinge and stove support. Note gratings through cabin sole to allow rain, spray, and wet clothing drippings to go directly into bilge. Note paired lazarette hatches in afterdeck.

Occasionally, in modern boats built of fiberglass or fiberglass-covered plywood, the fuel tanks, water tanks, icebox, and stowage bins utilize part of the hull in their construction and, in turn, contribute to the stiffening of the hull by their walls, tops, and partitions. See Plates 1-5, 5-5, 6-5. If you plan to relocate any such unit and find, after studying its construction, that cutting away one of the panels will endanger the boat's structure, you may be able to approach the problem by an exchange method.

Here is an example of such an exchange: you have put a larger engine in your motorboat and find that its increased weight makes the boat float too high forward, so that it runs very inefficiently when you have several people in the cockpit. Beneath the berth in the main cabin, the boat has one or more water tanks. Forward of these water tanks, still under the berths, you have storage lockers for life jackets, rope, fenders and similar "bos'un's" gear. If you remember that water weighs sixty-two pounds per cubic foot, you will realize that very few cubic feet moved a short distance forward will make a major difference in the trim of your boat. Now, if the tanks beneath the berths are metal or plastic installations and you can remove them without damaging them, they may have good resale value. By removing them you will make the space they occupy available to take over the duties of your bos'un's locker. The old bos'un's lockers can be bulkheaded off in plywood or fiberglass and lined with glass-reinforced polyester resin to make new water-storage tanks.

Another good way to convert these old lockers into tanks is by the use of flexible plastic bags. Some of these bags are available at war surplus under the classification of "airplane fuel-tank flexible liners." When filled with water, they will completely occupy the space left in your locker, no matter how irregular it is. Most such tanks have excellent filling and drawing valves so that your plumbing hookup is quite simple. Waterproof fabric pontoons are also good for this service. It is only necessary to scrub the exteriors thoroughly and flush out the insides with warm water and detergent so that no mold which the bags have picked up during their storage time can contaminate your water or the boat.

Alterations and conversions of this sort can genuinely improve the value of your boat, both in terms of the fun you will have from the work and its completion and the dollars at the time of resale.

### Ventilation

When a boat is at anchor, lying with her bow into the wind, the flow of air into the cabin is from aft forward. This is so because the forward hatch is at the area of greatest wind velocity and acts as a pitot in which a low pressure area is created. A pitot, you see, is an orifice lying at right angles to the flow of air or of a liquid. One of the fundamental laws of physics demonstrates that this arrangement of orifice and gas or

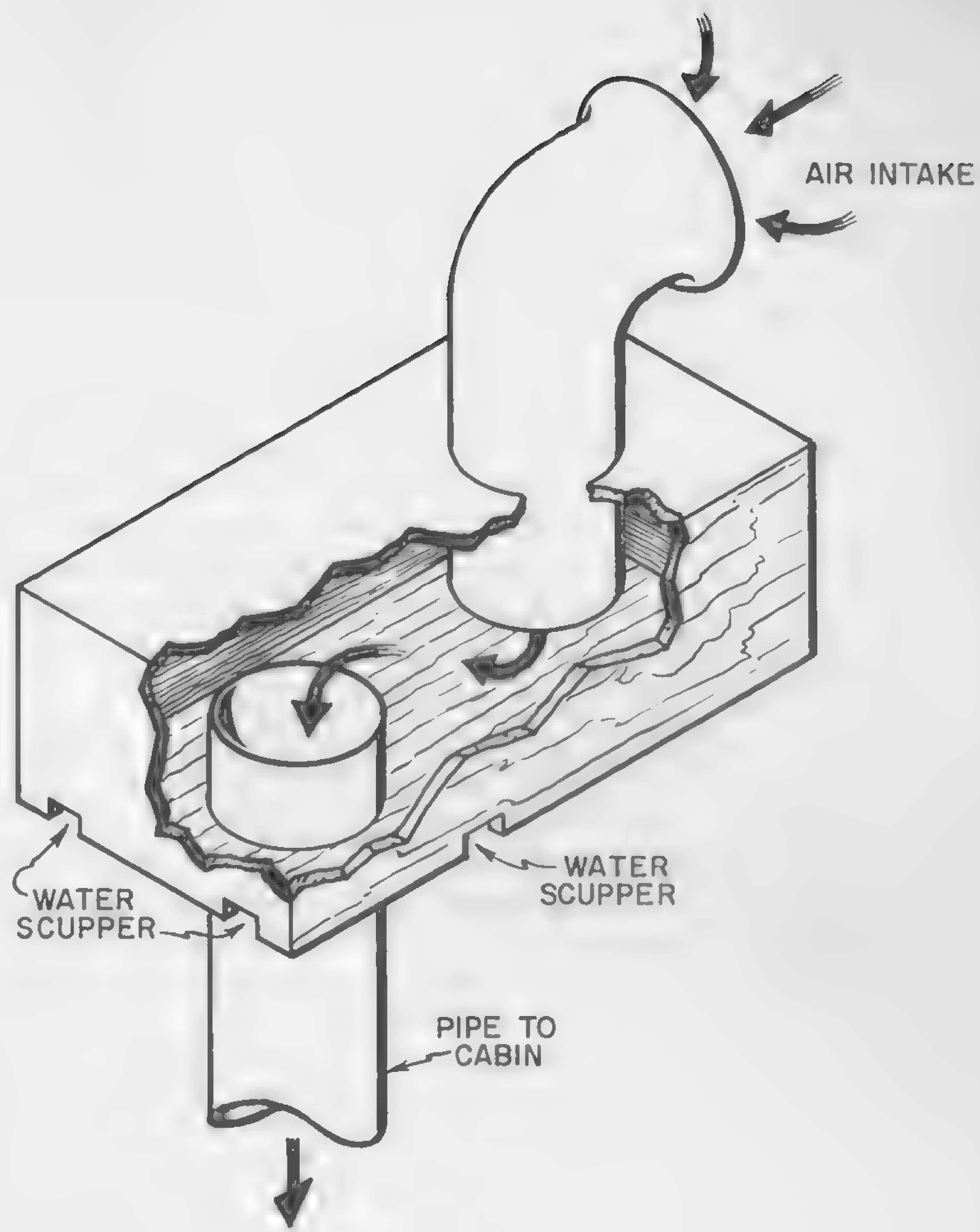



Plate 3-7. Dorade-type ventilator.

fluid motion generates a partial vacuum in the orifice. The air from within the boat rushes to this low-pressure zone inside the forward hatch to try to equalize the pressure and is carried aft by the flow of air outside. Replacement air feeds into the main companionway, the area of which allows great quantities of air to enter under low pressure. You can see that, to take advantage of this, the fewer obstructions you have to the normal air flow inside the boat, the more effective the ventilation will be. Typical obstructions are partitions, projecting lockers, narrow passageways and doors separating cabins.

Besides the main air discharge through the forward hatch, supplemental ventilation is often desirable over the galley and toilet areas. The most effective and simply installed watertight hatches commercially available are made by the Sudbury Products Company, in Sudbury, Massachusetts. While the initial cost of these hatches is rather high, they need no maintenance and show minimum deterioration over the years. Truly watertight, they can be rotated to take advantage of the direction of air flow when the boat is under way as well as at rest. Alternatively, the boatowner with a tight budget can easily construct a wind scoop as shown in the diagram. The face, or coaming, for such a wind scoop should be perfectly square in plan. See Plates 1-5, 9-5. This permits the wind scoop to be rotated in any one of four directions so that the opening is always facing downwind. The downwind position gives the greatest amount of pitot action and the best protection against the entry of rain and spray.

Closets, hanging lockers, under-the-bunk storage areas, sail and rope bins, should always be built with a screened or louvered front. Adequate ventilation here is more important than anywhere else in the vessel except the engine room. These areas are prone to gather moisture for several reasons: first, they include or extend into the lowest areas of the hull where heavier, moisture-laden air accumulates; the texture of the materials they contain, such as clothing, rope, and sails, tends to be hygroscopic (moisture-absorbing); there is least likelihood of sunlight entering these areas and sunlight is a natural enemy of fungus, mold, and rot. You will remember, in the first chapter, "The Right Boat for the Job," these were among the areas we inspected for signs of damage from rot and decay.

The cabin sole, in the areas where it covers the bilge, should also be provided with openings for fresh-air circulation. These openings can be located in a midships line at the fore and aft ends of the floor. These will be the areas where the least dirt accumulates and there is the smallest chance of bilge water splashing onto the cabin sole in rough weather. If you have wet-cell storage batteries in the living portion of the boat, be sure too that they are adequately ventilated. The fumes from these batteries contain chlorine, which is a severe skin irritant and is altogether poisonous in a confined space.



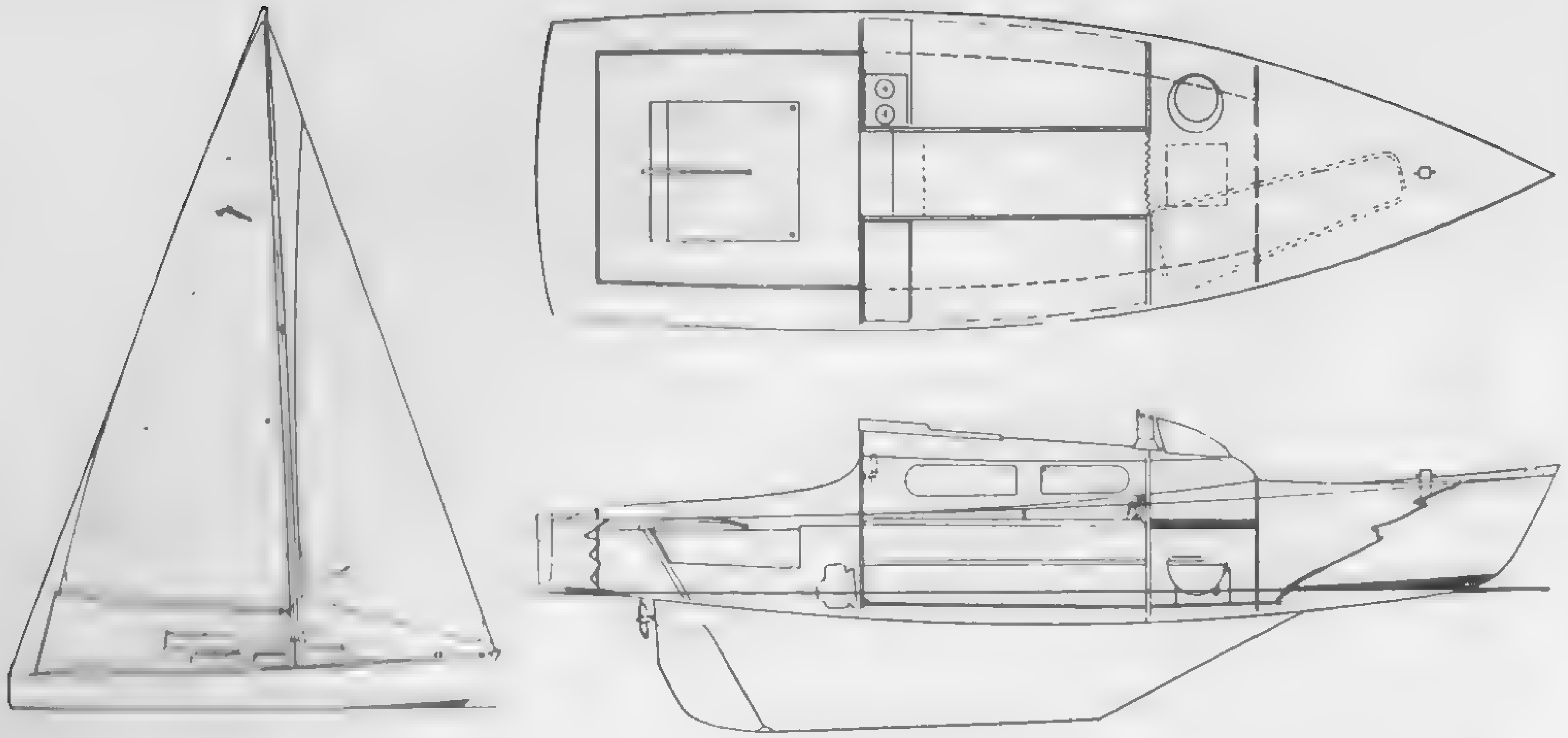
In general, portholes which can be opened on a small boat are abominations. It is almost impossible to make them truly leakproof. When they are open, they invariably discharge residual water onto the berth, and such salt water will forever after attract moisture. It is far better to get all your ventilation through deck hatches. Take care to locate your deck hatches in such a way that accidental leakage of waves or rain cannot do any harm. For example, if there is a double berth in the forepeak of your boat, it probably has a v-shaped area at its after end to partly separate the two halves of the berth. By locating a forward hatch over this area instead of over the berth itself, any water which enters will fall harmlessly to the floor.

Hatches through the top of the main cabin can often be located above the galley surface, the top of the icebox, or the toilet room and in these places, too, an accidental dollop of water is not harmful.

Pipes and openings in the forward deck through which the anchor line is passed are generally more open to rot than they are useful. In boats up to about forty feet of overall length, it is a much better idea to stow your anchor line in the cockpit and carry it forward when it is needed. If you use one of the modern, lightweight anchors which does not have to be assembled in order to be used, you can leave it attached to the anchor line and stow them together. For this type of stowage, coil the anchor line in generous radius turns. Then tie the coil with two or three turns of stopping twine at several points about its circumference. Stopping twine is also known as "rotten cotton." It is a very soft cotton thread, easily broken. Your sailmaker or marine-hardware dealers will have it in stock. This material also is ordinarily used for tying up sail, such as spinnakers which will be hoisted in a furled position, then broken out just by pulling on the sheet at the proper time.

Ventilation of the engine room should always be done separately from the ventilation of the living quarters of the boat. The reasons for this are twofold. First, the accumulation of explosive fumes from the engine room is made even more dangerous if these fumes enter the smoking and cooking areas of the boat. Second, free communication of the air in the engine room with the air in the living area of the boat allows engine heat and noise to disturb the occupants of the cabin.

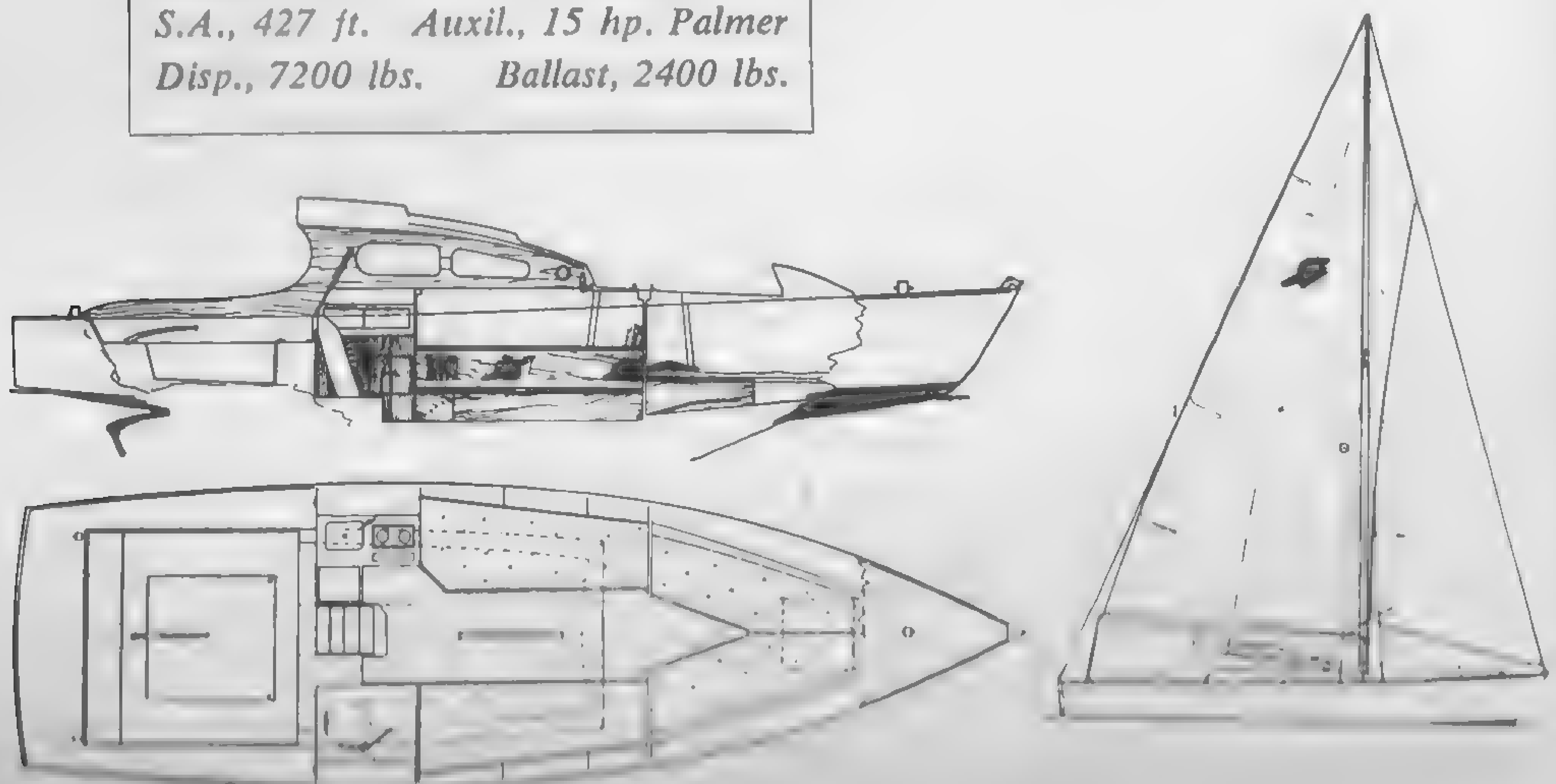
It is even more important that engine room ventilators be watertight than it is for the ventilators of the cabin. Water entering the engine room could short circuit the ignition system of the engine and leave you without power. Such a short circuit could also start a fire, with consequent danger of explosion. The simplest way to negate the danger of water entering the engine room is to build the ventilators in the shape of an inverted U. An alternative method is to build a water trap. This water trap is also called a Dorade-type ventilator because it was made famous by the brilliantly suc-



| | |
|---|---|
| *L.o.a., 23′0″* | *L.w.l., 19′6″* |
| *Beam, 7′0″* | *Draft, 3′0″* |
| *S.A., 260 ft.* | *Auxil., 6-hp. Palmer* |
| *Disp., 2000 lbs.* | *Ballast, 800 lbs.* |

Plate 4-7. This illustration shows comparison of two cabin layouts in boats that differ only 6′ in overall length. Note displacement differences and differences in power required to drive them 6½ knots. (By the author; originally published in *Yachting* magazine, December, 1957.)

| | |
|---|---|
| *L.o.a., 29′0″* | *L.w.l., 26′6″* |
| *Beam, 8′6″* | *Draft, 3′6″* |
| *S.A., 427 ft.* | *Auxil., 15 hp. Palmer* |
| *Disp., 7200 lbs.* | *Ballast, 2400 lbs.* |



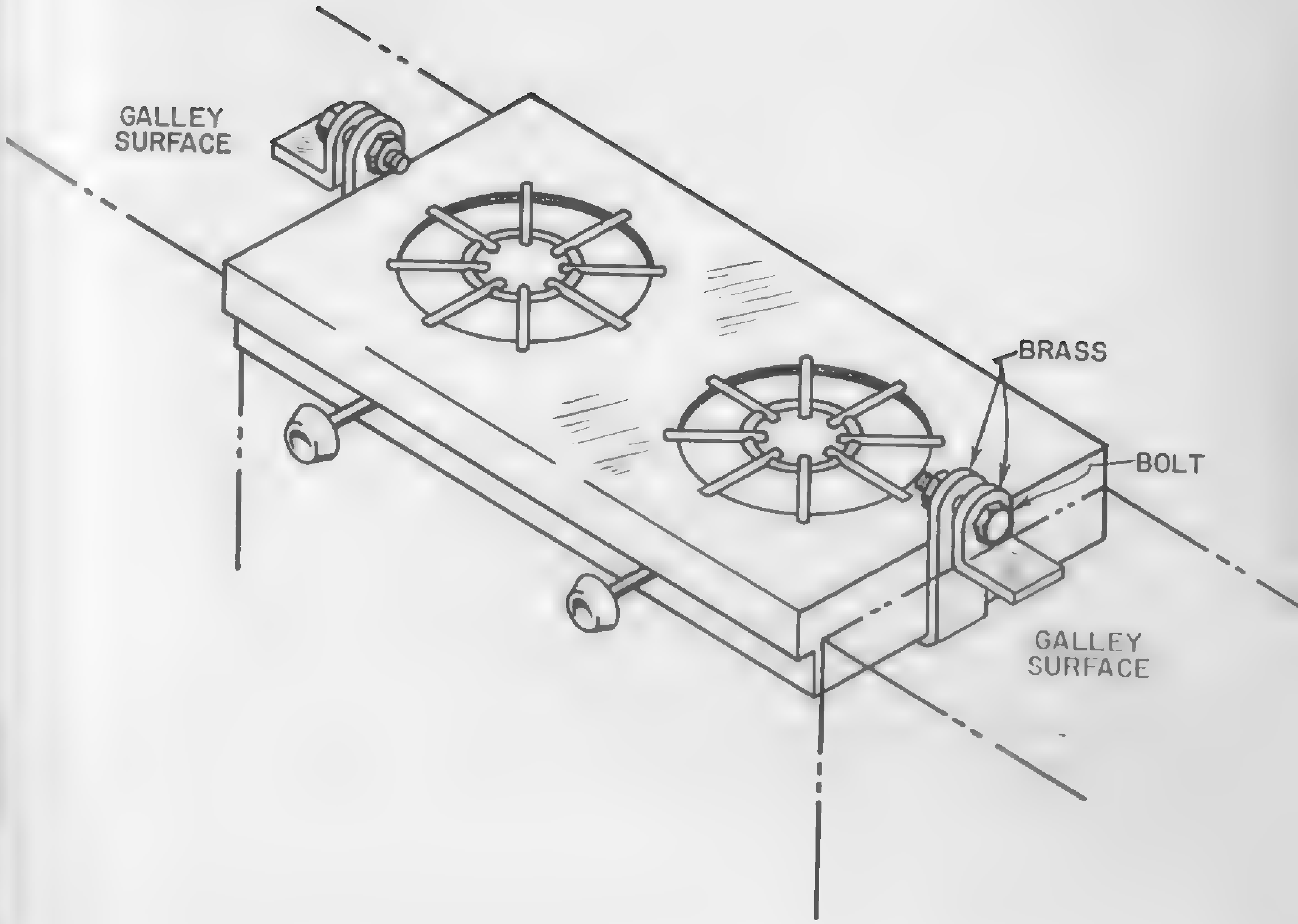



Plate 5-7. Method of gimballing galley stove.

cessful racing yacht of that name. The Dorade-type ventilator is illustrated in the drawing. See Plate 3-7.

The pipes from engine room ventilators should reach nearly to the bottom of the bilge. This is because the vapors of both gasoline and oil are heavier than air, and always settle to the lowest part of the boat. You must reach for them down there, but do not run the pipes so deep that their ends are in danger of being shut off by bilge water. Remember that an adequate air supply is a fundamental necessity for the proper performance of your engine.

### The Galley

First consideration for the galley in a boat is its location. In small craft where there is no problem of privacy between the owner's party and a professional crew, the galley should always be located aft near the companionway. This is near the area of least motion in the boat. It is well ventilated by the main companionway so the cook will have plenty of fresh air and freedom from violent movement of the vessel. These are some other advantages in this location: when you are sailing singlehanded, it will be easy for you to keep an eye on the stove and, in bad weather, warmth from the galley will be a comfort to those huddled about the companionway; the cook has easy access to serving the crew in the cockpit; loading of food supplies and ice is facilitated and these items can often be stored directly from the companionway. If the surface of the icebox is immediately to hand inside the hatchway, it makes a convenient chart table and navigation surface for the singlehander and, when racing, a convenient liaison point for communication between navigator and helmsman. See Plates 2-7, 4-7, 6-7.

One of the galley's most important considerations is the material with which it is surfaced. While stainless steel is frequently used on the working tops, it is expensive, heavy, scratches readily and, despite its name, stainless steel will rust. Far better and less expensive surfaces are Formica and linoleum. Although slippery, Formica is highly resistant to damage from heat and abrasion and is readily cleaned. Linoleum, somewhat more easily stained, is nevertheless obtainable in nonskid surfaces. The slippery surface of Formica makes it impossible to use in rough weather or when the boat is heeled, unless some sort of antislip measures are taken. The usual remedy is to use a large sponge-rubber pad. An equally good arrangement can be improvised from a towel. Soak the towel, wring out all the excess water, then lay the towel out smooth on the Formica. It will grip very well, holding both the Formica and the utensils firmly.

If your boat is too small to provide a large gimballed cabin table on which food and serving utensils can be placed without danger of spilling, linoleum is your logical choice for a galley surface. Any of these products



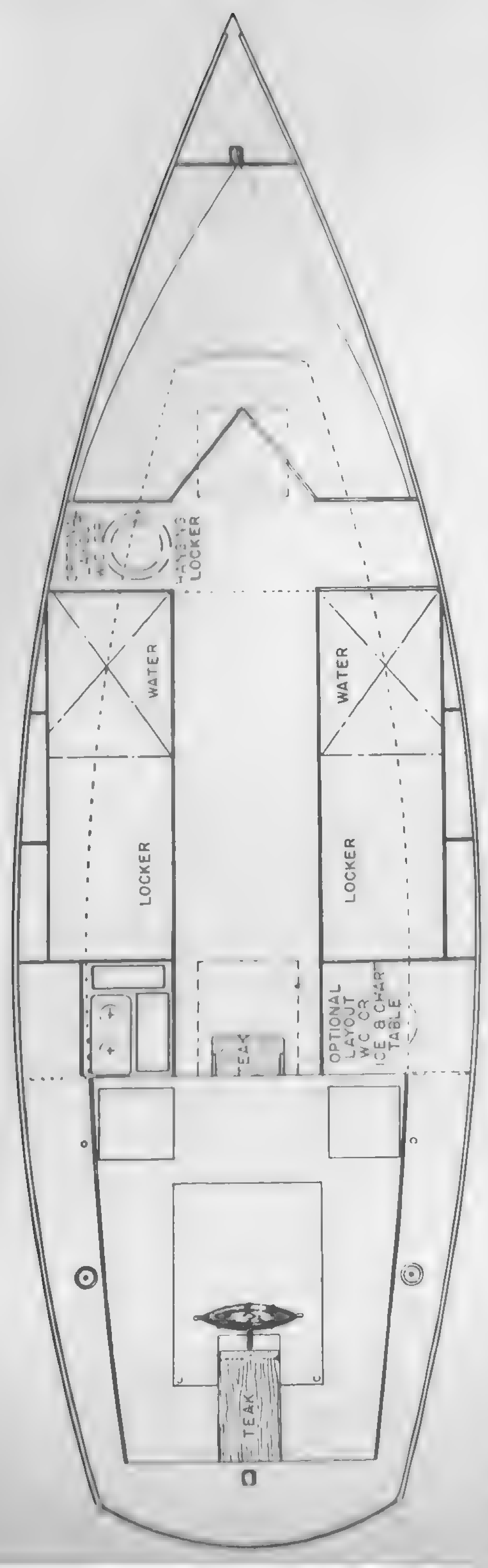
can be attached to the original galley surface by the use of contact cements. These are adhesives which are painted on each of the surfaces that are to be put together. The adhesives are allowed to dry to the touch. Then, before letting the pieces touch one another, they are accurately positioned in their permanent relationship. Once the surfaces touch, they are fastened together for all time and cannot be shifted. For this reason it is usually a good idea to tear several long strips of wax paper and lay them on the contact cement which has dried on the galley counter. You can then position your surfacing material directly on the wax paper sheets and, lightly holding the new surface in place, pull the sheet from under it. Once adhesive contact has been made, you can pummel the new surface with your fists to be sure it is everywhere adherent to the cement beneath it. Be especially careful that no areas of bare wood exist beneath the surface or show between its cracks and joints. Such surfaces become the repository of fresh water and soon are attacked by rot.

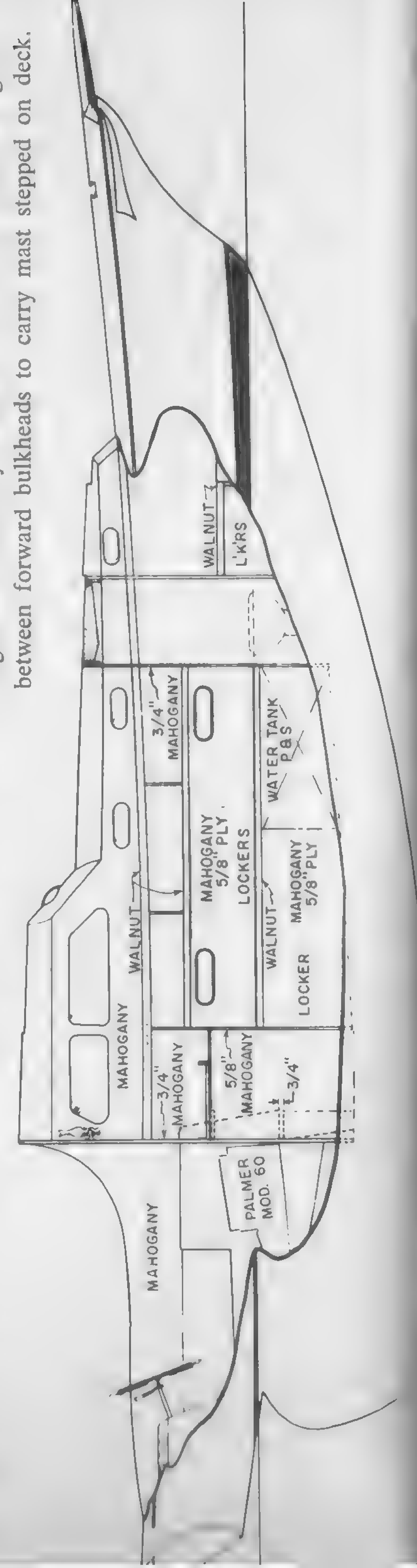
### *The Stove*

Although in this age of intercontinental missiles some excellent bottle-gas stoves have been produced, insurance company statistics show them to be unsafe. Current restrictions prohibit the use of gas stoves drawing fuel from self-contained pressure bottles. Stoves which burn gas from bottles located on the deck, having cut-off valves at the bottles and piping the gas to the stove below, are clumsy, rust-attracting devices. It is also difficult in many ports to purchase refill bottles. Under most insurance rulings, your second bottle must also be carried on deck, which multiplies the stowage problem. These are the reasons why most boats today burn alcohol, kerosene or Sterno. Of these, the alcohol stoves are often the most practical. Many work by gravity feed and some of the best are manufactured by Wilcox-Crittenden in Middletown, Connecticut. They are especially safe because there is no danger from pressure leakage and because alcohol flame can be put out with water.

The best kerosene stoves made in the United States are manufactured by Coleman Company. Their newest models are extremely neat and foolproof and do not require priming by a separate fuel. These new Coleman stoves generate as much heat as the gravity-feed alcohol burners and make no mess or dirt. However, kerosene fire must be fought with an extinguisher.

The Sterno stove burns jellied alcohol in self-contained tins. The flame can be extinguished with water. Instantly ignited, it is entirely safe from explosion and altogether clean and neat. The only drawback to the Sterno stove is that it is impossible to regulate the heat. You will find that, for most boat use, this drawback is unimportant. Sterno is cheap and readily obtained everywhere.




5-7. This boat was designed for the jockey Logan Batcheller who constructed it in fiberglass himself. Cockpit seats are 6' long, flush for out-... Twin cockpit hatches give both sides of engine access. Engine access also through hatch in after cabin bulkhead. Full-size main berths, short-size forward cabin berths. After toilet position gives 5'10" headroom, same over galley. Note forward hatch located so ends of ... berths can be used for steps, but after-lip of hatch is between berth "V" so cannot drip on sleepers in bad weather. "Blister" on doghouse is Sudbury ventilator. Note also metal web girder between forward bulkheads to carry mast stepped on deck.

On any boat in which you will cook while under way, it is worth your while to rig the stove in gimbals. The gimbals are a hingelike arrangement which hangs the stove so that it always remains level. This can be easily done as shown in the diagram, but you must be sure that the axis of rotation has been properly chosen for your boat. Remember that a sailboat requires most of its gimballing in port and starboard directions. This gimballing can be copied from the rings of your boat's compass. In all cases, the weight of the stove and the pots on it are the pendulums through which the gimbals act. See Plate 5-7.

It is worth mentioning at this point that liquid-filled fire extinguishers have been recognized as extremely dangerous. Contents of the most common one generate mustard gas in the presence of heat. The cheapest and most practical extinguishers today are those which yield carbon dioxide.

### *Sinks*

The quick, cheap and practical way to build sinks today is from polyethylene tubs, readily available in any hardware store. They are used for washing or as refrigerator boxes.

If your boat is large enough to make a built-in sink drain worth your while, you can fit the polyethylene box with a chrome-plated brass sink-drain unit. This can be purchased for a few cents from any plumbing supply house. In most small boats it is entirely satisfactory to cut an aperture in the galley surface into which the polyethylene box will fit. To empty the box it is only necessary to lift it from its aperture and throw the contents from the lee side of the boat. The principal advantages of the polyethylene sink are low cost, resistance to abrasion and puncture, ease of cleaning and maintenance and a surface against which dishes will not break. Ordinary chemicals such as soaps, detergents, bleaches and scouring products leave the polyethylene unharmed.

### *Galley Water Supply*

If the water tank of your boat is located in the cockpit, it is usually possible to feed water into the galley by gravity alone. However, in most boats today, particularly those used for racing, the water supply is located deep within the boat and generally at a considerable distance from the galley sink. In these cases it is necessary to use a pump to draw the water to the sink. Such pumps are available in a variety of forms but all of them are rather expensive. However, there are some plastic bilge pumps made of polyvinyl chloride, which are obtainable in extremely small models. They are neat and foolproof and can be fitted with polyethylene garden hose leading from the intake end to the water tank. Among conventional galley pumps, the most effective are those which work by diaphragm. You see,

with a diaphragm, there are few problems of leaking check valves on the priming side of the pump. The initial cost of the pump is also low because accurate and expensive pistons and cylinders are not necessary. Variations on these latter forms of pumps can be made by using foot-operated diaphragm-type bilge pumps which you hook into your water line or rubber squeeze bulbs provided with check valves, such as are used to start the syphoning of fuel or water. Some of these syphon systems are available at war surplus where they are referred to as "medical-supply transfer syphons for liquids." These rubber bulb systems are also useful for draining excess icebox water, for withdrawing the last bit of fuel from dirty tanks, or for transferring alcohol or kerosene to fill your stove.

*The Icebox*

The simplest way to construct an icebox is to build a chest of marine-quality plywood covered on the inside with fiberglass-reinforced polyester resin. See Plate 1-7. This chest should be built smaller than the area into which it will fit, so that you have ample space to cover the outer surface with fiberglass insulation batting or insulating sheets of polyurethane-foamed plastic. A one-inch thickness of insulation will suffice. However, there should be an additional space of at least one full inch between the finished chest and the hull of the boat. Holes should be bored so that air may enter and leave at the top and bottom of this ventilation area. It is imperative that you provide this space to protect the boat against attack by condensation from the chilled air at the surface of the box. Don't forget to insulate the cover of the box to the same extent that you have insulated the sides. A generous drain hole should be provided at the low point of the ice chest to carry off water from the melting ice. Drain the water overboard, if possible. Otherwise, collect it in a sump and pump it overboard. The drain hole should be not less than one-half-inch in diameter or it will clog with particles of food wrappers and food itself.

As mentioned in Chapter 10, "Running the Boat," the use of dry ice is a real asset in providing space and gaining maximum food preservation. A practical way to employ dry ice is as follows: purchase a large sack of ordinary ice cubes; sprinkle a layer of these one cube deep along the bottom of the box; on this layer of ice cubes set your block of dry ice; now build a mound of ice cubes around the dry ice to cover it on the sides and top. This aggregate will soon solidify into extremely thick water ice with a dry-ice core. It will provide you with excellent refrigeration and also with accessible water ice to use for chilling drinks. Remember that this refrigeration method creates an area of extreme cold. Do not put liquid-filled bottles or tins into the chest unless you have first protected them with insulated paper bags. Otherwise the liquid contents will freeze and burst.



Any icebox designed for boat use should, if possible, have its opening at the top. Side-access iceboxes are dangerous in rough weather conditions. Not only is there a hazard of food flying from the box but if a large cake of ice runs amuck it can smash up the boat and possibly injure you. Remember, too, that most fruits and vegetables will keep better off ice than on it. You should provide a well-ventilated latticework bin somewhere in the galley area for these fresh products.

**Cabin Lighting**

Lighting is a simple problem in a small cruiser because central illumination can be used to flood the entire cabin. While some excellent fluorescent tubes are available which will run from low voltage systems, these, like ordinary light bulbs, should never be used in exposed positions. The principal hazard here is accidents from broken glass in rough weather. Secondly, however, the moist salt air can create a voltage leak which is difficult to detect but which will run down your batteries without your knowledge. For this reason dome light fixtures are recommended everywhere throughout the boat's interior. The dome of glass provides some protection against airborne moisture. It is wise to have all interior illumination draw its current from a battery separate from the engine.

You can purchase an inexpensive battery charger known as a "trickle charger" which, operating from 110 volts at the dock, will keep your boat batteries filled. Such a charger can be built in as a permanent part of the electrical system. Fitted with a waterproof outside socket, a dock line can be run to the cabin of the boat bringing 110 volts through the charger into the battery and operating lights and radio whenever you wish. A secondary lead-in wire for 110-volt current can be installed at a safe place in the boat so that, for dockside living, electric shavers, electric toasters, electric fans or vacuum cleaners can be operated. There are also convertor units on the market which will change your direct current six or twelve volt battery source to 110-volt alternating current. If you plan to purchase one of these units, check first with the company that manufactures it to see if it will provide ample wattage for the appliances you intend to operate. In general, you will need at least 35 watts to run ordinary household appliances. It is a good idea also to provide at least one 110-volt lamp socket to take a conventional household bulb for cabin illumination at dockside.

The convenient, practical, economical, watertight way to bring additional light into the cabin without loss of privacy is to fabricate hatch covers or hatches themselves of translucent fiberglass-reinforced plastic. Such sheets are commercially obtainable from Russell Reinforced Plastics Corporation, Lindenhurst, Long Island, New York. If you specify in your letter to the Russell Plastics Corporation the use you intend to make of

their sheet, they will recommend size, thickness and method of attachment. Mr. John Turner, Research Engineer of Russell Plastics Corporation, is a pioneer in this sort of work. He is also an experienced boatman and can give prompt answers to your problem requirement.

### Berths

While built-in cabin berths are usually standard equipment on every boat today, it is often desirable to provide additional berthing for racing or family cruising. The conventional pipe berth, consisting of a frame of metal tubing to which a canvas surface is lashed, which carries the mattress, is simple to install and may be removed from the boat for storage ashore. See Plate 4-7. This convenience allows you to provide extra living room without carpentry and, at the same time, such berths are easily cleaned and dried ashore.

Berth mattresses today are best made of foam rubber covered with a textured plastic for their protection. In warm climates it is altogether impractical to use smooth plastic over mattresses. Rough surface material permits air circulation under the body and does not reflect body heat and moisture. While the rough-textured material may be somewhat more difficult to clean, it also shows less dirt and provides better anchorage for cushions and pillows in bad weather. Although the top, sides and ends of the foam-rubber mattress can be covered with such a solid plastic, it is wise to cover the under side of the mattress with open-weave fabric, such as burlap. Clean commercial burlap can be purchased from bag-manufacturing concerns and can be readily stitched directly to the plastic. By thus enabling the entire mattress assembly to breathe, you avoid the formation of disagreeable odors and prevent mildew from growing inside the mattress cover.

When stitching mattress covers with synthetic thread, such as nylon, adjust your sewing machine for close spacing and use the smallest needle practical. Nylon thread is very strong and can tear its way through the toughest plastic if the pull against the needle hole is local and uneven. Small close stitches prevent this problem. Cabin pillows and cushions should be made in the same way as mattresses. Here, however, all sides of the pillow and cushion are covered with plastic but vented brass grommets are located at several points around the perimeter to allow air to escape in and out through the cover.

Aboard the sailboat, you will find bunkboards essential to sleeping under way. These can be made from varnished mahogany or cedar and are boards which fit between the berth and mattress to provide a lip or rail extending four to six inches higher than the sleeping surface. Bunkboards fit into slots built up by scraps of wood attached to the bulkhead at either end of the berth. For daytime use the bunkboard is removed from its slot



position and stowed flat under the mattress. This provides you with sitting comfort during the day and sleeping security when you are off watch.

### Color Psychology

While color psychology may sound as if it were a personal equation, you will find that there are basic reasons why the science came about. There are two fundamental problems involving color inside a boat. These problems are diametrically opposed to one another so we must solve them by compromise methods. First, some darkness is desirable in a cabin because of its restful qualities to the eye which has spent hours in the glare of sun, sails and water. The most simple available way to obtain these colors is to take advantage of wood bulkheads, cabin trunks, berth bases and shelving. These natural woods can be waxed or varnished to provide the dark tones of the boat's interior.

Juxtaposed to these dark tones, the under side of the decks, the skin of the hull itself, the cabin sole and the inner and outer surfaces of the cabin top should be kept as light as practical. A light-colored cabin sole prevents accidents by increasing visibility, and helps you find lost or fallen articles. Light colors on the inner surface of the hull and under surface of the deck resist the formation of mold and fungus, most of which proliferate in the absence of light. The cabin top itself will reflect most of the heat of the sun without transmitting it into the boat if light colors are chosen.

You will find in choosing these light colors that the pastel ranges of grays, greens and blues combine a feeling of spaciousness and cleanliness with subdued glare. Very light yellows also fall into this class but accentuate each flaw in the grain or finish of the natural woodwork. Colors taken from the warm side of the spectrum like reds and browns should only be used for bright spots or trim inside the cabin. Such colors are focal points for your attention and when distributed over large areas inside the boat do not provide sufficient orientation for your vision to allow your eyes to come to rest. Your susceptibility to motion sickness is a function of the fluid in the semicircular canals of your ears plus the ability of your eyes to fix upon a holding point. If you are prone to seasickness you may have noticed how staring at the horizon, even though it be from a porthole below deck, has a strong corrective tendency for your discomfort. Large areas of attention-getting color make such focusing difficult and add to the discomfort of those who already are ill.

### Handrails

The most useful and most often neglected accessory inside the cabin of any boat is the handrail. Installation of a single rail from the inside of the cabin top along the center line provides security and comfort on the sea.

Alternatively, rails port and starboard in the boat running along the cabin sides at their junction with the deck can also be developed out as shelving. Handrails in the toilet room and galley areas should be located at shoulder height. This is a height at which you can most easily exert the proper strength to resist the great weight shift of your body in rough weather.

Handrails can be made from wood, from pipe, or from plastic tube. The polyvinyl chloride, high-impact, thick-walled pipe is strong, of light weight, and inexpensive. It needs no maintenance and looks clean and businesslike. However, it is best used inside the boat and not outside because long periods of exposure to intense sunlight weaken the material and this forces you to use much heavier stock than would otherwise be necessary. The two principal requirements of handrails are: ample clearance, permitting one's hand to get a firm grip without fumbling; strength enough to resist the really great force of a falling person. This means that the mountings or supports of the handrail must be big enough to hold the rail clear of the surface to which it is attached, strong enough to resist a heavy surge of force, and extensive enough to accept proper fastenings for securing them to their working surface. Most commercial sockets for railings have adequate strength but insufficient clearance to permit a large hand to firmly grip them. It is usually necessary to cut filler blocks of wood which fit behind each support and increase its distance from the mounting surface. A neater alternative is to make a plywood pattern and take it to your foundry for casting. Your foundryman may already have some excellent patterns just for this purpose. This is a very common type of casting and, because the commercial fittings all seem to be inadequately designed, almost everyone who thinks about the problem makes a pattern of his own.

**Toilets**

The toilet or water closet, generally referred to on plans as WC, is in use the least number of hours of any accommodation in the boat. Because of this it is unwise to sacrifice large amounts of accommodation space to gather comfort in the toilet room. It is sufficient to allow a useful working area with enough room for ease in cleaning and to locate the toilet properly in that area. In power boats it is entirely satisfactory to face the toilet fore and aft or athwartship. The motion of the boat is about as extensive in one of these directions as in the other. In the sailboat, however, the predominant motion is from side to side. Therefore, the sailboat toilet should be mounted so as to face the center line of the boat. That is, it should face athwartship.

It is common in boats today to provide full head room for standing at the toilet. See Plates 2-7, 4-7, 6-7. Actually, this is undesirable in boats



which will be used much under way. It is altogether impossible to keep a marine toilet room clean from soilage if the water closet will be used from a standing position. If you have the tact and forcefulness to command your crew members to be seated when under way, the standing head room can be a delight when the boat remains at rest. One timorous but experienced owner has solved the problem by the use of an oversized removable medicine chest. Before starting a cruise he installs the chest in the toilet room where its bulk precludes any use of the equipment in other than a seated position. Back in his home anchorage the turn of a toggle releases the chest, which he stows in the lazarette until the next cruise is planned.

**Screens**

Screens for hatches, ventilators, and companionways are a necessary adjunct to summer cruising. One simple approach to the problem is to screen the entire boat as a single operation. This can be accomplished by purchasing a war-surplus screen tent. Such a tent will cover the entire cockpit area of a large cruiser and often will even extend far enough forward to include the forward hatch. In a sailboat or an auxiliary, the tent can be held up by the boom or hoisted from the mast. No attempt is made to seal the edges around a tent of this kind. Instead, one depends upon the excess screen material lying gasketlike against the deck or hull to act as a seal. Of course, along some of our waterways where the mosquitoes cooperate with each other, two or more may lift the edge of the tent while another crawls beneath it. You will find, however, that securing the tent edge against a very few points, like scuppers, cleats, or handrails will be enough to hold it. If you get a sufficiently strong wind to disturb the net, it will also blow away the insects.

The most common method of screening is by the use of framed inserts which slide in grooves beneath the companionway hatch and behind the companionway door, and screened hatch covers which rest on moldings around the perimeter of hatch coamings. On the wind-scoop type of forward hatch the screen can be a permanent fixture built from the inside. You should not make the screen extend across the horizontal plane of this forward hatch or you will be troubled by birds using it as a roosting place. Instead, screen off the more or less vertical plane, the opening of the hatch designed to point downwind.

The screened frame which fits the top of the main companionway can be supported by moldings attached just below the grooves in which the hatch slide runners operate, but be sure you allow enough clearance so that the hatch will not be jammed if the screen frame swells from moisture. If the vertical portion of your companionway is ordinarily closed by drop boards or sliding panels, you can design the screen frame to work in the

same channels. If your drop boards are made up as two or more separate units, design the screen framing to duplicate these units in size. This will enable you to choose several different openings to best fit your demands for privacy or climate control below deck.

A sort of compromise between the tent approach to screening and the accurately fitted slides is the net curtain. Here, the width of netting is made up six inches wider than the companionway on either side and a foot or so longer than the sum of the length of the opened hatchway butt vertically and horizontally. The edges of this netting are hemmed over so that a piece of cotton rope or shock cord can be passed through on the left and right sides. If shock cord is used the upper ends are hooked to hatch runners and the lower ends to the deck at the bottom of the companionway. Mosquito netting can be freely pushed all the way up or down the shock cord to get it out of the way or to cover over the opening. If rope is used instead of shock cord, the ends can be cleated down or, as an alternative, the net can be sewn fast to the rope and the lower edge weighted so it will remain in place.

All the plastic and fiberglass screens available today are good. They are superior to metal screens because they do not corrode, they are completely flexible and, if they are punctured or distorted, they recover at once because of their natural flexibility. These synthetic screens are superior to the ones made from natural fiber because they cannot be damaged by rot, do not hold moisture to attract mildew and will not support combustion or carry fire. This last factor can be serious if a net cockpit tent is used where people are smoking aboard the boat. Be certain, if your net is not an incombustible synthetic or a metal, that it has been soaked in a fireproofing chemical. Such liquid chemicals are available to coat industrial fabrics and camping and military equipment and can be purchased from campers' supply stores.

CHAPTER 8

# In the Boatyard

## OWNER-SHIPYARD RELATIONS

THE WORKING ASSOCIATION of good will between the boatowner and the owner or manager of the shipyard which regularly does his work is an invaluable asset to pleasure boating. The firm foundation on which this relationship should be built consists in mutual understanding of the problems of the boatowner and the yard, and the expressing of all work contracted between them in fair, simply written form.

Before contracting with the yard to do any work, you should first go over the boat, itemize those jobs that you feel are necessary, and discuss them with the yard owner. Give the yard time to consider the job and properly estimate the cost and time of the work. Then ask them to schedule the work in such a way that it best fits in with their winter plans and forms a logical sequence in the workmen's schedule. By thus programming the jobs you wish the shipyard to do on your boat, you permit them to distribute the work in a way that keeps their help evenly employed, and they, in consequence, can offer you the best price for their services. Regardless of the informality of your association with the yard and the friendly level on which you conduct your business, it is poor management to make verbal contracts. These can easily lead to misunderstandings, and not only between the contracting parties. If, for example, you should sell the boat during the lay-up period, the new purchaser will demand an itemization of the responsibilities he has incurred.

A formal statement of the work you have requested the shipyard to do, plus your statement of those jobs you intend to do yourself, should be mailed to the yard and you should keep a carbon copy in your files.

Ask, in your letter, that the yard confirm it, referring to it by date, or duplicating it in their answer.

Most small boatyards live a precarious economic existence. That is why it is usual for them to request part payment for the winter storage of your boat immediately upon hauling. Generally, too, the yard will restrict the work that you can do yourself. Often they will demand the right to paint the exterior and the bottom of the hull and to do any carpentry below the waterline. It is important that you know exactly what you yourself are permitted to do on your own boat before you haul in any particular yard. Otherwise, you may find yourself charged for expensive maintenance costs simply because you are not permitted to do jobs that you thought you could handle yourself. Among those jobs that the owner is generally permitted to do are covering the boat for the winter, removing the cover in the spring, any and all interior work and work above the decks, unrigging and rerigging of the spars, all work on the dinghy and all work on the sails or engine, as well as work on the propellers and shaft.

During lay-up season, an owner who has a workshop can save a great deal of overhead by sanding and refinishing hatches, spars, shelving, cables and furniture, and overhauling the galley stove, the engine and the deck gear at home. It is obviously unfair to the yard if the owner hires outside laborers and brings them in to work on his boat while it is on yard property. If you do not feel confident or economically secure in the yard you are using, it is better business to change over to another boatyard than to put your boat and yourself in an atmosphere of strained relations. Remember, too, that by paying your bills promptly, the total cost of ownership of your boat will actually be reduced. The reason behind this is that the yard which has ample funds in its treasury can afford to hire workmen of a quality that the struggling boatyard cannot afford.

### Haulout Procedures

You can greatly simplify your life and working conditions in the boatyard by proper preparations prior to haulout. Remember that when the boat is on its cradle all access to the interior will be by shipyard ladder. It therefore makes sense while the boat is still in the water to remove all those things that will be taken ashore or stored in your home during the lay-up period. Run the boat alongside a dock or float that is a convenient working height from the deck. There you can remove all food from the icebox, left-over ice, the dinghy, mattresses and cushions, personal belongings, and those spars which you can lift yourself. If you plan on pulling the mast for the winter you will next take the boat around to the mast derrick. Be sure, before pulling the spar, that all rigging electrical connections are unfastened from the mast. Now, too, is a good time to scrub down the decks, cockpit, topsides and cabin trunk because, in the yard, hosing the boat down will create an area of mud around it. If your boat is shaped unconventionally below waterline, tell the yard of this before they put her on the cradle and if a set of plans, showing your underwater profile, is available it will be a great asset in preparing the cradle before hauling the boat. Except for those men which the yard puts aboard, there should be no one in the boat while it is being hauled. Until the final shoring is put onto the cradle it is unsafe to have shifting weight on deck because it might topple the boat.



### *The Cradle*

The cradle is that basic framework upon which the boat is actually stored while in the yard. Generally made of wood, it is often set on a railway carriage which rides upon the track leading from the yard into the water. Because the boat and its cradle are transferred together from the carriage, it is important that the cradle fulfill several distinct functions.

The first requirement is that the cradle conform exactly to the contours of the boat at the points where the boat makes contact with it. This insures the secure mounting of the boat so that it does not shift either in its transportation from the water to the land, or while the cradle itself is being transferred to its winter resting place in the shipyard. Most cradles consist of a permanent base, heavily built, and designed to fit the carriage. This basic cradle is tailored to each individual boat. Sometimes, in the larger yards where many different boats are handled every year, there is a stock of prefabricated shoring in a wide variety of shapes and sizes. These units are made so that they quickly slide on to any cradle. With such an arrangement the shipyard can approximate the shape of any boat it hauls. Wooden wedges are used to complete the fitting of the shoring units against the boat.

During the state of actual haulout the boat should be secured at four points along the topsides, paired off as twin supports on either side. Temporary vertical shorings should be placed fore and aft so that the boat can't tip down by the nose or the stern during the jerky motions along the railway. Once the boat and cradle have been transferred to their resting place in the yard, strong vertical supports at the bow and at the stern, particularly on boats with long overhang, are necessary to prevent sag during the lay-up time. Additional shorings should also bear up against the hull of the boat at the turn of the bilge. This is usually done in the areas just forward of the rudder post.

Further forward, similar shorings should come up to support the boat somewhere about a distance of one-third of the total length from the bow. Such shoring should not contact the specific local area of the planking of the boat. On the contrary, it should distribute its load-bearing characteristics via large pieces of scrap lumber. This more accurately simulates

the support the boat gets from the water when it is afloat. If the shoring contacts at small areas only, it can seriously injure planking, the hull, or its fastenings at these points. In the case of a sailboat with a large amount of ballast stored inside against the hull, tremendous loads are put on the planking, its fastenings and the seam caulking when the boat dries out during the lay-up period. If the spars are left in the boat during the winter, it is important that you slack the major portion of the tension on the stays and shrouds, for they, too, can pull up very strongly against the chain plates, the planking and the stem at a time when the boat with its planking shrunken has the least uniform support from each of its structural members.

Well-designed cradles have preassembled shorings which slide athwartships to the axis of a boat, along the cross timbers of the cradle. This design enables you to move one shore at a time to work on the bottom for scraping, caulking or maintenance. Then you can replace the shore as quickly as you are through with the job and move on to the next one. This type of sliding shoring should be arrested by wedges driven between each shore and the cradle, so that there is no danger of accidental shifting of the supporting members during lay-up. In a boatyard where you are a regular customer, special shoring and a cradle are put aside for you so that each time you haul you will be assured proper fitting, seating and security of the boat.

It is worth remembering that boatyard ladders are migratory animals. You and other patrons of the yard will swap ladders many times during normal lay up. Be sure, then, before you remove a ladder from a boat that you have not stranded someone aboard. If a ladder has the name of a specific boat marked on it, it probably is the personal property of the owner of that boat and, as such, you should respect it and leave it alone.

Immediately upon hauling, when the bottom of the boat is still wet, you can remove most of the marine growth with a long-handled scrubbing brush and a high-pressure water hose. Once this fouling has dried, it becomes very difficult to remove it from the hull. All the loose bottom paint will generally flake off easiest after the bottom has dried. When cleaning the bottom, an old, dull, hack-saw blade is an excellent tool for removing barnacles and fouling from the water intakes, the toilet discharge, the cockpit bailers, around the propeller shaft and between the rudder and the deadwood of the boat. If your boat has drain plugs in the bilges, remove them after the bottom has been cleaned and let all the bilge water run out. When the boat is dry inside, lightly grease the caps and screw them firmly back into the plug holes. Set them in place firmly so you won't forget them at spring launching time and run the danger of having them come loose and sink your boat.



*Coverings*

There is nothing so destructive to the well-being of a boat as the formation of ice in the bilges, seams, cracks and openings. Just as ice can split water pipes on shore, so in a boat it exerts tremendous pressure as it expands. It can tear apart planking, frames, floor timbers and fittings. Your best protection against this danger is proper covering of your boat.

Intended primarily to protect a boat from all the elements of weather, the cover must also provide adequate ventilation for the interior of the vessel. To insure a proper flow of air everywhere in the boat, the cover should be set up over a scaffolding or framework, which raises it above the deckline. During the winter months the air is heavily laden with moisture. This wet air can provide an environment favorable to mold or rot, and the situation is aggravated because winter sunlight heats the air under the cover. The ultraviolet rays themselves, however, do not pass through the cover to arrest mold formation. Therefore, you must provide adequate circulation of air so that the free oxygen will destroy incipient mold.

When you make the cover scaffolding, allow sufficient height so that you can easily get in and out of the boat to work during the winter and spring months. The scaffolding can be of rather light stock. Perhaps the best materials to use for this are wood 2 x 4's athwartships, a 2 x 4 for the fore and aft backbone, like the ridgepole of a rafter system, and several light fore and aft battens to keep the cover from sagging with accumulated snow and water.

You can make a good cover for your boat inexpensively by stitching up medium weight canvas (about eight ounces) and coating it with neoprene waterproof paint. Be sure the edge of the canvas extends a long way over the topsides of the boat. Down to the waterline is not too far. Hem the edges up in a generous seam along their entire end and length and fit them with frequent brass grommets through which you can feed tiedown ropes to keep the cover from tearing loose in winter gales. A section of large diameter, galvanized stove pipe fitted with elbows so you can bend the parts through ninety-degree angles will provide good ventilation. Because of the downward bend of the exposed part of the pipe, rain, vermin, and snow cannot enter. You will need a pipe at either end of your cover. Secure it with generous lashings so that it cannot come loose and blow away. Leave open the drain holes from your self-bailing cockpit, but plug all other through-hull openings, such as the exhaust pipe, toilet outlet, and icebox drain, with long, wide scraps of cloth, allowing enough material to stick beyond the hole so that there will be no difficulty in removing it before spring launching.

The purpose in letting the cockpit drains remain open is to insure that snow or rain accidentally working under the cover cannot accumulate and freeze to split the pipes. The normal through-hull fittings are protected by nature of their installation against this condition. They are not protected, however, against snow blowing in from outside the boat and from the nesting of insects and vermin. Some of this nesting, particularly that of insects, may accumulate in the bends and elbows of the plumbing and be nearly impossible to clean out without dissembling the pipe line.

Hatches, mast openings and open-deck fixtures can be covered with scraps of plywood retained in position by weights such as rocks or inside ballast. This is good protection against vermin and possible leakage of snow. Inside the boat, open all hatches, cupboard doors, icebox lids, and stowage compartments, and let air pass freely everywhere it can. The floor boards should be removed and when the bilges are dry and the water tanks drained, all accumulations of dirt should be cleaned out with rags or with a sponge. By allowing the bilges to dry thoroughly during lay-up period, you permit them to prepare themselves to receive wood preservative before you go overboard in the spring.

**Winter Work in a Shipyard**

Winter is an excellent time for the removal of old paint, varnish, and other finish from the boat. This is so because you will fatigue less easily working in the cold. Chemical removers used on the old finish do not dry as quickly as they do in summer sun and there is less chance of interfering with other boatmen during these times when the yard population is at its lowest. You will find that just a few hours of work during the warmest part of a winter day, carried on throughout the week ends, will bring your boat a long way toward final fitting out in the spring.

It is important, however, to guard against leaving any surface from which you have removed the old finish exposed to the ravages of cold weather for any length of time without protective surfacing. This is particularly true of bright work and trim. Highly finished woods from which the old varnish has been scraped quickly grow rough and discolored when exposed to the damp chill air. As soon as you have removed the finish down to the material beneath, resurface it with a thin priming coat. This will protect the wood, the metal or plastic, against the ravages of winter and will give you a firm foundation for a new finish in the spring. You can, for example, clean off an area of several square feet during your week-end work and immediately apply a primer to that surface to protect it until you return the following week. Then, when you come to the yard again, you can resume work at the edge of that area where you left off last. It is most important never to leave seams, cracks or holes in which water may gather and ice form.



**Courtesies in the Boatyard**

The first courtesy you should accord the boatyard is to remember that you are only paying for space, labor and materials in your contract. You are the guest of the yard and should treat your host with the same respect you give to your hosts on land. Many yards provide rental tools and sell hardware and paints. These facilities are maintained for your convenience but you must remember that the yard helps support itself by selling or renting them. When a dozen boat owners plug in electrical appliances which they have rented elsewhere, or borrow half a dozen wood screws each, they make a serious dent in the boatyard's economy.

While boatyard owners must earn money to live, they have no illusions of growing rich at their trade. They have chosen their work because they are interested in boats and the people who operate them. It is fortunate for yachtsmen that most professionals are eager and willing to share advice. Again, however, you must remember that these professionals earn their living by selling their time and labor. When you are working on your boat, it's for fun and relaxation. The professional does it for a livelihood. Just as your family doctor sells advice and skill, so do the carpenter and painter, the rigger and plumber sell their knowledge and their work. A quick way to become unpopular among these artisans is to seek their counsel so that you can avoid hiring them for the actual work.

In all walks of life, good manners are merely the reflection of common sense. If, during your stay in the boatyard, you consider your fellow sailors at every turn, you will win friends and avoid unpleasantness. On the other hand, the fellow whose disc-sander sprays old finish onto the freshly painted topsides of the boat downwind is not only in for a few unpleasant moments, but perhaps a lawsuit for his carelessness. Be careful that you don't create areas of mud when using water and hoses. These muddy bogs not only are a hazard to people walking through but can cause fatalities by providing an electrical ground to workmen using power tools. On this same theme, which might be called "Inviting the Undertaker," the chap who uses a power tool which doesn't have a grounded wire in the circuit is taking his own life in his hands. This is a danger equal to that of using power tools from a raft or rowboat or while standing barefooted on the ground. Under these conditions, the workman becomes an excellent conductor and even a mild power leak is capable of delivering a serious electrical shock.

**Recommissioning**

The very first step in recommissioning your boat in the spring should be to put the engine and other greasy parts in working condition. Then, still before scrubbing, painting or varnishing the boat, attend to all jobs

on the interior which will be done while the vessel is still in the yard. The reasoning behind this project is that you will be climbing in and out of the boat at a furious rate. This includes dragging boatyard dirt, greasy equipment, black rubber electric cords, hoses, and the grit from your shoes, everywhere on the boat. When the mechanical aspects of the interior have been brought up to launching condition, you can tackle the refinishing of the interior woodwork. It is safe to attend to this even in the early spring, which is usually the rainiest part of the year. The interior work of paint and varnish can be drying to a hard finish when you later work on the exterior of the boat.

Next in the schedule it is wise to do the exterior bright work. You see, drippings of varnish on the deck and topsides can be more easily sanded and covered up with paint than the paint itself can be removed from the bright work. Once the trim and scupper rails are finished, the cabin top and deck should be attended to. Again you see, you are working from the top of the boat to the bottom. Accidental splashes of paint overflowing through the scuppers onto the topsides are easily attended to at this time. Next, as we discussed earlier, the topsides and bottom should be properly finished, in that order. It is wise to paint the topsides before the boot top; do the boot top before applying the bottom paint.

Some types of bottom paint should not be allowed to dry before launching the boat. This is always indicated in the instructions on the can. If you should use one of these brands, it is a good idea to put a little water in the bilges early in the season, after the last danger of frost has passed. This will swell the garboard plank and the plank immediately adjacent to it and reduce early spring leakage in wooden boats. Fresh water in the bilge should contain liberal amounts of salt which you can sprinkle in by hand. Remember that fresh water is a primary source of rot in wooden boats.

Also, before launching, the bilges should be drained dry so that in the event of leakage you can immediately track down and attend to the source of trouble.

If your boat was tight during the previous season, don't be alarmed at open seams so long as they show no light. A seam through which daylight can be seen is dangerous and must be puttied. Remember, too, upon launching, that boats built of hard, dense woods like oak, yellow pine and mahogany, swell far more slowly than boats built of cedar, white pine and fir. As much time as a week may elapse before the boat is tightly swelled. Because of this, it is important that you don't make a final engine alignment or tightening of engine holddown bolts until the boat has taken its shape for the season. Drawing the engine shaft coupling too tight at this time and running the engine more than necessary may tear loose the stern bearings, or the deadwood itself.



When the water dried out of the wooden skeleton of the boat during the winter, each component part experienced an individual shrinkage in all dimensions. Built-up curved wooden members tend to change the radius of each curve proportionate to its size. Often, curves of a dried-out boat show little uniformity and are quite unfair. Moreover, each plank and frame is of somewhat different dimensions and physical characteristics. This condition, added to the other problems of shrinking and swelling, aggravates alignment problems even more. Now, when you realize that an engine-shaft lack of alignment of only some one-thousandths of an inch is enough to cause serious vibration, you will understand how small the likelihood is that the shaft bearing and the engine, several feet apart, have retained their exact relationship to one another from season to season. You will probably have to hook up your engine and shaft before launching so that you can move the boat clear of the ways and onto its moorings. Such use of the engine should always be at dead slow speed. During this time of swelling, the less you run the engine, the better. In fact, if you can avoid using it altogether until the wood of your boat has taken on its normal complement of water, you will avoid risk of any damage to the engine beds, floor timbers, shaft log and deadwood.

Once the hull has swelled, break the shaft couplings and, with a thickness gauge, align the engine so that it runs without vibration. The thickness gauge is inserted between the faces of the shaft coupling and the shaft is slowly rotated. When the engine and shaft are in line, the spacing of the faces of the couplings is uniform all around.

It is wise not to set or secure your mainmast until the boat has swelled. Tension on the shrouds and stays will put a severe initial strain everywhere on the boat. It is for this reason, too, that boats are never driven hard under power or sail during their first few weeks of use each spring. Now, just before launching, check such through-hull fittings as the exhaust pipe, toilet lines, bailers, and drain plugs to make sure they are leak proof and free of obstruction before you launch. Have the yard lower the boat on its cradle to about half its normal floating depth. The boat should be stopped at this point, while you go aboard to observe the extent of leakage.

If the boat leaks so severely that the water actually streams in, have the yard lower it to its designed waterline and then raise it very, very slowly, stopping when the waterline is a few inches above the surface. If much water has accumulated in the bilge raise the boat just enough so that the water inside is an inch or two higher than the water outside. Then stop again and let the water within the boat run out. When the water inside is once more at sea level, raise the boat an inch or two and let it drain. The object of this is to keep the tremendous weight of water in the bilge from exploding the planking from the boat. Remember that your boat was put

together to resist water pressure from the outside. Pressure from the inside is great in proportion to the strength direction of the construction of your boat. If you think of the construction of a wooden cask or barrel, you will realize that the hoops are driven around the outside to compensate for the pressure within. In normal boat construction the framing, analogous to the barrel hoops, is inside the boat. You can imagine that, if the hoops were inside the barrel, the barrel would simply fly apart. This will explain the forces acting on your boat when she is under pressure of the water from within.

Now, should the boat have leaked this badly, let her sit in the yard overnight and try launching her again the following day in the same manner. Even that short-time wetting of the planking may have swelled it sufficiently so that from now on you will experience no serious leaking. If, however, after this second try, on the following day, the boat still leaks dangerously, you must lay her up for caulking or for puttying the seams. A detailed discussion of this is given in the chapter on "Construction" and the chapter on "Outfitting the Boat."

## *CHECK LIST*

### Preparing for Haulout

1. Remove food and ice from icebox.
2. Scrub icebox with hot water and detergent; drain and dry thoroughly; prop lid open to provide ventilation.
3. Remove all other foods, including those in tins.
4. Remove mattresses, cushions and bedding.
5. Remove sails. Synthetic sails may be left in bags; cotton sails should be thoroughly dried, protected against insects and rodents by liberal sprinkling with camphor and stored in bags in dry place.
6. Remove anchor lines, all but one anchor, all nonsynthetic rope.
7. Remove compass, clock and barometer and store in dry, warm place.
8. Remove clothing, books, and papers and store in a warm, dry place.
9. Scrub galley surface and stove. Dry thoroughly. Spray rust-protective oil on all parts which can oxidize.
10. Remove silverware and cooking utensils, to be cleaned at home.
11. Remove exposed light bulbs, such as those in binnacle, running lights, and exposed cabin lamps, wipe sockets clean and coat with thin film of oil. Treat bases of bulbs in same manner and replace in sockets.
12. Scrub toilet room and toilet with hot water and detergent, and dry.
13. Remove medicine-chest contents, scrub chest and, if signs of rust have begun, touch up with spray enamel after scraping surface.
14. Remove inside ballast from bilges.
15. Add liquid detergent to bilges (detergent must be added separately to bilge between each set of floor timbers).



16. Scrub bilges thoroughly.
17. Pump bilges.
18. Drain water tanks. If they drain into bilges, again add detergent and pump dry. (The detergent in this case is to slough down waterborne contamination which may have originated in the tanks and could grow on the damp wood.)
19. Thoroughly scrub down cabin top, cabin, deck and topsides.

### Sailboats and Auxiliaries to be Unmasted

1. Bring boat to masting area.
2. Remove boom, gaff, and disconnect all lines running from these to the mast.
    a. Boom downhaul.
    b. Boom vang.
    c. Gaff bridle.
    d. Halliards.
    e. Topping lifts.
    f. Undo watertight collar where the mast passes through deck.
    g. Disconnect all electrical connectors to mast.
3. Slack headstay until it just begins to bow.
4. Slack backstay until it just begins to bow.
5. Slack upper shrouds port and starboard, alternately loosening them a few turns at a time.
6. Remove running backstays from deck attachments.
7. Bring boat into position beneath masting crane.
8. Have yard attach lifting eye to mast. Check to be certain it is held in its up-down position by a strong line attached to a strong winch or cleat. Be sure lifting eye cannot rest against spreaders.
9. If partner wedges are used around mast, remove them.
10. Have yard take up slack in hoisting cable.
11. Slack off lower shrouds.
12. Remove clevis pins from all shrouds and stays as quickly as possible.
13. Have yard pull mast straight up very quickly and see that foot of mast is several feet above deck and will clear all obstructions before it is swung over the land.
14. Lay mast on temporary supports and remove all rigging, labeling each part as it is taken off and immediately replacing nuts, bolts, clevis pins and cotter pins on the spar.
15. Remove masthead light bulb, clean socket, clean base of light, lubricate and replace.
16. Lay mast out absolutely straight in storage area.
17. If mast must be stored out of doors, wrap it with roofing paper in such a manner as to make a coat which is waterproof.
18. Store wires flat or in large-radius coils. Coil ropes. Store all away from exposure to the weather.

19. Booms and gaffs should be stored in same manner as mast unless they are small enough to be taken home and worked on during winter.
20. Cover mast hole in deck with plastic or plywood top securely taped so it is waterproof.
21. Move boat from masting area.

### HAULOUT

1. Bring boat to cradle. The boatyard will give directions for properly entering upon the cradle.
2. Be certain the boat is secure upon the cradle.
3. Stop engine and open electrical switches.
4. When cradle begins to move, remain seated at center line of boat.
5. As soon as cradle is in shallow enough water workmen should insert wedges under shoring.
6. Do not attempt to leave boat until the yard foreman procures a ladder for you and tells you it is safe.
7. Scrub bottom of boat immediately after hauling, while it is still wet.
8. Unless it is necessary, do not board boat again until it is moved to storage area and properly shored.
9. Open through-hull drain plugs.
10. Pump toilet dry.
11. Drain engine water.
12. Remove batteries and have yard put them on continuous trickle charge throughout winter.
13. Lay up engine as outlined in "Engine" chapter.
14. Sponge every final drop of water from the bilge.
15. If boat will be stored outside, prepare winter covering.
16. Remove hatches, doors, screens, engine boxes, blocks and other work which can be overhauled and refinished at home.
17. Plug all through-hull holes except cockpit self-bailers.

### CHECKS DURING WINTER

1. Check that cover is secure.
2. Check for adequate ventilation (stale or musty odor shows inadequate ventilation).
3. Check through-hull plugs.
    a. Exhaust pipe.
    b. Toilet (two; intake and output).
    c. Engine intake.
    d. Icebox drain.
    e. Sink drain.
    f. Bilge pump drain.
4. Check against invasion by rodents, birds, or insects. If necessary, sprinkle heavily with camphor or spray.



5. Check to see that shoring has not been moved.
6. Check to see that shoring is adequate and boat does not appear to be changing its shape. (Sometimes it is difficult to judge changes in shape when a hull is covered. Look for the symptoms, which are irregular appearance of planking, uneven opening of seams.)
7. Check to see that cover reaches an adequate distance down the hull so that snow and ice can't accumulate in the dried-out seams. (It may be necessary to run an extra band of fabric around the boat to extend your cover if you discover that it is inadequate to protect the boat.)
8. Check the cover against sagging and tearing from accumulated ice and snow. (Extra supports for the cover may be required.)

### MIDWINTER CHECK INSIDE THE BOAT

1. Check against ice forming in bilges, cockpit or drain. (This may come from cover leakage, from inadequate coverage, via the ventilators in violent blizzards, or condensation on warm days. Treatment: sprinkle ice liberally with rock salt.)
2. Loosen spark plugs or injectors. Turn engine over several revolutions by hand. (This redistributes the oil on the cylinder walls. During storage gravity brings the oil down so it accumulates just on top of the pistons.)
3. Inspect for mold by visual and odor check.
4. Inspect parts containing corrosible metal.
    a. Galley stove.
    b. Engine tools.
    c. Engine exterior.
    d. Turnbuckles.
5. Water level and charge batteries.

### WORK THAT CAN BE DONE AT HOME DURING WINTER

1. Refinishing of hatches, ladders, doors, small spars and motor boxes.
2. Building lockers, drawers, shelves.
3. Overhaul of stove.
4. Overhaul of toilet.
5. Overhaul of engine parts for entire engine.
6. Reupholstering.
7. Sail repairs.
8. Making sails.
9. Overhaul of rigging parts such as turnbuckles, blocks and winches.
10. Refinishing dinghy.
11. Building spars.
12. Reinforcing transom of outboard boat.
13. Overhaul of trailer for small craft.
14. Cleaning down to bare wood and fiberglassing hulls, spars, center-

board and centerboard trunk, rudder, hatches, and icebox.
15. Construction of fiberglass-covered plywood tanks for fuel or water.
16. Construction of fiberglass-covered fish, bait, and tackle boxes.
17. Making wood patterns for casting accessories in bronze.
18. Overhauling galley pumps, bilge pump.

### Preparation for Spring Work

1. Remove cover, dry and store in camphor flakes for summer.
2. Remove and dry framework supporting cover, labeling parts so they can be easily reassembled in the fall.
3. Remove spark plugs, or injectors, and turn over engine by hand several times.
4. Repack all grease cups and lubricate all engine parts.
5. Wirebrush rust from engine and repaint with engine enamel if necessary.
6. Thoroughly dry and ventilate bilges, water tanks, fuel tanks, icebox, and all lockers.
7. Brush wood preservative on wood surfaces:
    a. Mast step.
    b. Mast aperture through deck.
    c. At base and deck aperture of sampson posts and bitts.
    d. Along both sides of keel from top of stem inside boat to top of horn timber aft.
    e. Behind and under icebox and in area of bilge into which icebox drains.
    f. Area of bilge beneath toilet, galley and lavatory sinks.
    g. On deck at points to which chain plates and other through-deck fittings open.
    h. Wood in area where wet clothing or oil skins are ordinarily stored.
    i. Base of mast.
8. Sand and refinish mast and spars.
9. Sand and refinish interior of hull.
10. Sand and refinish exterior of hull starting from highest point and working down, but not applying bottom paint or striping boot top.
11. Hook up engine and plumbing.
12. Hook up interior plumbing.
13. Remove plugs from through-hull fittings and exhaust pipes.
14. Lubricate sea cocks for through-hull fittings.
15. Tightly replace all hull drain plugs.
16. On wooden boats, wet down exterior of hull with gentle stream of hose as frequently as possible; at least once a week. After hull has begun swelling put a little water into the bilge, bringing the level up to about one-half the height of the floor timbers in order to swell the garboard planks.
17. Test bilge pump.



### Before Launching

1. Be sure bilge pump is working.
2. Have one extra bucket aboard in case it is needed for emergency bailing.
3. Close all sea cocks except those necessary for the engine (engine water intake lines and exhaust pipes).
4. Be sure two or more fire extinguishers are on board and in working condition.
5. Put aboard at least one anchor and proper anchor line.
6. Install engine-starting battery.
7. Check engine-oil level and oil level in gear box.
8. Put mooring lines aboard.
9. Put fenders aboard.
10. See that engine tool kit is aboard.
11. See that engine manual is aboard.
12. See that horn, megaphone or others means of signaling for attention are aboard.
13. Check steering gear and be sure rudder is operating.
14. Check engine controls to be sure they are moving the proper parts of the engine in the proper direction.
15. Be sure engine is connected to propeller shaft.
16. See that propeller is secured to shaft with a locking key and cotter pin through the propeller retaining nut.
17. Throw engine in neutral gear and turn propeller from outside to make certain it rotates freely.
18. Check packing in propeller-shaft gland.
19. Check packing in rudder-shaft gland.
20. Paint bottom of boat, paying particular attention to get antifouling paint between deadwood (aftermost edge of underbody) and rudder; centerboard and well; bottom of keel (this will mean jacking the boat first at bow, then at the stern to get access to the areas of keel which rest upon the cradle) and under shoring. Antifouling should also be worked in the holes of through-hull fittings under water.
21. Paint boot top.
22. Put aboard sufficient fuel in one engine tank to run the engine at least one hour. (Be sure filler spout from fuel transfer can is in contact with metal fitting on fuel-tank filler pipe so there is no chance of generating a spark by static electricity.) Start engine, permit it to run for several seconds, then cut it off immediately before it gets hot.
23. Have boatyard move boat and cradle onto railway carriage for launching.

## Launching

1. Be sure boat is secure on cradle and carriage.
2. Be sure cradle is attached to carriage so it cannot float off with the boat.
3. Place anchor and attached anchor line in convenient position on deck. Be sure bitter end of anchor line is tied to boat.
4. Have a long mooring line coiled in the cockpit so it can be thrown to the yard men if necessary.
5. Have yard lower the boat until the water comes about halfway to the flotation line.
6. Inspect the bilges to see how much she is leaking. If you cannot tell whether or not she is leaking to excess, have the boatyard foreman give you his opinion. Your decision, however, should be your own. If she is leaking at a rate such that she could be easily pumped at intervals of about an hour or more, continue launching.
7. Before the boat floats clear of the cradle, start the engine and adjust it until it is running smoothly. If the engine will not start, or misbehaves, the boat can conveniently be brought alongside the dock without it, and it is safe to do so provided the boat is not leaking seriously.
8. Keep the boat pumped so that the level of bilge water never exceeds more than about one-half the height of the floor timbers. If this becomes too great a physical task even with boatyard help, arrange to haul again at once.
9. Under no circumstances leave the boat unattended until the leaking can easily be controlled by one man after an interval of six hours.
10. If leaking is beyond control within the limit set above, have the boat hauled as quickly as possible.
11. After swelling is complete, unbolt flange faces of engine-shaft coupling and realign engine.
12. After engine has been run about fifty hours, change oil and oil filter. (Oil may have been contaminated by condensation and its by-product of oxidation.)

## Stepping the Mast

1. Check bulbs for masthead and spreader lights.
2. Attach halliards.
3. Attach boom-topping lift.
4. Attach shrouds and stays.
5. Tape all cotter pins.
6. Tape or lash shrouds at spreader tips.
7. If boat has jumper shrouds on mast put them under equal tension, sufficiently tightened to just bow mast forward when mast is not in boat. This amount of bow should be the minimum curvature that you can perceive when you sight along the spar with your eye close to it.



8. Check sail track for roughness or damage during rigging operation.
9. Do not attempt to put mast in boat until leaking is within easy control.
10. Lightly lash all rigging to mast with several turns of thin cotton string.
11. When water is calm and there is little or no wind arrange with yard to step mast.
12. Attach turnbuckles to lower ends of rigging wire, and open turnbuckles until they are about three-fourths extended.
13. Have all clevis pins and cotter pins ready for attaching turnbuckles to chainplates.
14. If boat is large, station one man on deck to guide mast, another man below to seat it in its step.
15. Lower mast into place.
16. Attach lower shrouds to chainplates and tighten just enough to take slack from wires.
17. Attach jibstay and backstay(s) to boat. Tighten to remove slack.
18. Attach upper shrouds.
19. Drop in wedges which act as partners at deck. Never drive these into place.
20. Tape or lash mast coat to make it watertight.
21. Even up tension on all rigging wire but do not set any of it tight until boat is swollen and has, therefore, its full strength.
22. Attach booms.
23. Connect electric lines to mast.
24. Wire and tape turnbuckle attachments and barrels. Turnbuckles must be prevented from rotating after shrouds have been set to final tension.

# CHAPTER 9

## Tuning the Boat

THE 1958 races for the defense of The America's Cup were outstanding examples of the importance of tuning in yachts. In the United States, four boats created by three capable designers competed in an elimination series from which the final defender was selected. It is significant that the winning boat and the runner-up in this elimination contest were only separated by seconds in the final race. The loser and the winner had been designed by the same man at the ends of a twenty-year interval. Conceived under a very rigid rule, the greatest difference between these boats was age alone.

The challenger from England, having but one other boat against which to race and tune herself, was hopelessly outclassed. Although on the race course the American yacht *Columbia* and the British yacht *Sceptre* seemed worlds apart, their actual time difference over thirty miles of distance could be measured in minutes and seconds. Now, the hulls of these two boats were as different from one another as the confinements of the rule under which they were built allowed. But both hulls were limited, not only by their shape but by the efficiency of their sails, trim, wind resistance, and the efficiency of their individual sails. With the exception of her spinnakers, which were superb, the British yacht *Sceptre* had some of the worst setting sails a yacht could carry. Although new sails were made for her during the race series, she never overcame this initial handicap. However, there was a striking improvement in her performance after the second race when she received a new Genoa jib.

Francis Herreshoff, one of the leading yacht designers of all time, has





said that the condition of a boat's bottom, rig and sails are probably of more significance to her performance than minor variations in hull form. Conditioning the hull, the power plant, the rig and trim of your boat are as important in cruising as they are in racing. The best racing boats and the best cruising boats are identical with one another in this respect. The cruiser must be fast enough to reach her cruising ground in a reasonable period of time and seaworthy enough to do so safely in any weather. The racer must be comfortable enough to permit the crew to work and rest efficiently. It is important to realize that success in cruising or racing is never attributable to a single stroke of inspiration. The racer who captures trophies and the cruising man who explores out-of-the-way harbors both depend on every detail of their boats performing perfectly. The reliability of their equipment is the end product of patient step-by-step maintenance and improvement. Such work is not a program of drudgery; it is, on the contrary, an expression of pride and of interest. But best of all, it pays dividends in trouble-free boating and in the delight of making your boat an instrument which is always prepared to respond at once to the demands of her master's skill.

### Finish

In the low range of speeds at which boats generally travel, the greatest resistance they encounter is that caused by skin friction. Such friction is a function of the actual area of the boat that is immersed in water. Now, if the bottom of the boat were absolutely smooth, we could find the surface area with a bit of simple algebra. Then, at low speed, we could say that the way to reduce the resistance between the boat and the water would simply be to reduce the area immersed. Boats, however, are not that smooth. If we looked at a boat bottom with a lens of great magnification, we would see the major irregularities in the hull itself, smaller irregularities in the material of which the hull is made, and the still smaller tips and peaks which exist in the finish coating of the hull. All these tiny areas of roughness react with the water so that the true surface area of the immersed portion of the boat may be more than twenty per cent greater than the measured area.

For any given engine or sail plan, the less surface which the available power has to move through the water, the higher the speed of the boat will be. Conversely, with the cruising power boat, at any given speed, the amount of fuel the engine will consume will be reduced in proportion to the amount of power saved when a smooth surface makes the boat easier to move. Such a saving in fuel can amount to many gallons in the course of a cruise and this in turn means a greatly extended cruising radius without refueling. Detailed instructions for building a fine finish are given in Chapter 3. Here we merely emphasize the need for the ultimate in smooth-

ness where high performance is important. Whether sail or power, out-and-out racing craft should concentrate on bottom smoothness even at the expense of incurring antifouling problems. More races are won at the maintenance level than in the cockpit of the boat as it travels about the course. While smooth enamels and burnished copper paints on the boat bottom require great care, you must be prepared to pay the price in work, if you are seriously hunting for trophies.

**Weight**

Uffa Fox, who has designed some of the fastest sailboats ever built, has pointed out that the only place in this world where weight is important is in a steam roller. This can be taken as a fundamental law of boat design and it applies as much to the power craft as it does to the sailboat. One of Newton's laws of motion describes inertia by saying that a body at rest tends to remain at rest and a body in motion tends to remain in motion. Whether you drive your boat by engine or sail, you have only a given amount of power with which to overcome the total resistance of the vessel. Part of that resistance will be the resistance of inertia. You know how, when you have had to push your automobile, it took tremendous force to get the car rolling but, once it was in motion, little effort was needed to keep it under way. Starting and stopping the motion of a heavy mass consumes tremendous energy. Your boat must stop and start to some extent each time it hits a wave. The heavier the boat is, the more energy will be be absorbed. You can see then that the light boat which accelerates quickly and rises over a wave, instead of trying to drive through it, will hold the highest average speed for a given amount of power. Even in ballasting, if we can get stability from the shape of the boat instead of from weight, or from a small amount of weight hung very deep, the boat will be the better for it.

Referring again to the 1958 races for The America's Cup, the English yacht *Sceptre* was designed as a heavy-weather boat in preparation for the autumn wind off Newport, Rhode Island. During the first several races, while the winds were light, the *Sceptre*'s performance was bad. However, optimism still ran high in the crew. They felt that when the wind finally increased to autumn average, their extra weight would carry them over the waves while their lighter competitor, the *Columbia,* would waste much of her energy starting and stopping. It was also felt that the *Sceptre*'s greater weight would carry her through the head-on seas without loss of inertia. When the wind finally came, the *Columbia,* which was several thousand pounds lighter than the *Sceptre,* accelerated so quickly and rose so lightly to each oncoming sea that she outran and outpointed the *Sceptre,* which followed her hopelessly.

The first place from which weight can be removed is the storage area of



the boat. Most boats accumulate a great amount of plumbing and hardware fixtures, carried as spares for replacement and repair. The racing boat must leave these ashore, even as she will also have to leave behind unnecessary rope, extra anchors, anchor chain (for which must be substituted nylon or Dacron rope), excess spare food, extra books, magazines and charts not pertinent to the areas in which the racing will be done, and spare sails or engine parts not really necessary for high performance. The serious racing man will also choose a crew of wiry, lightweight men and he will keep the crew to the minimum. Every extra man carried requires extra food, life jacket, berth and mattress, water, and personal gear. The racer will carry an inflatable rubber raft, instead of a dinghy, in order to save weight. Boathooks, fishing equipment, swimming ladders, and other sporting gear are other examples of unnecessary weight. Often, considerable weight can be saved by replacing wet-cell storage batteries with lightweight dry batteries for all services except starting the boat's engine.

**Stability**

When we come to the question of stability in boats, Francis Herreshoff has said of it that wise men cannot measure it and that even fools know the thing to do is to increase it. Two ways to increase stability are removing weight above the waterline and adding to weight below the waterline. Cargo craft like freighters have a height called the "metacenter." This is a mythical point above which any weight added to the vessel decreases her stability, below which any weight adds to it. Some people who are interested in black magic have tried to apply this concept to small craft. You will find, however, that by following the two principles just stated you can bring your boat to its maximum stability with no mathematics at all. In the sailboat, begin by changing all your rigging pulleys to those made of light stainless steel or plastic. The Tufblox lines of rigging blocks and Racelite fittings provide tremendous weight and windage saving at low cost. You can even make similar parts yourself from sheet stainless steel or Monel. Remember that one pound of weight at the top of a twenty foot mast can exert a leverage of twenty foot pounds. It does not take many ounces of weight saved to decrease this lever action materially.

Now consider gear that can be lowered in the boat to increase stability. Your old water tanks can be abandoned and new ones made of fiberglass and plywood installed into the turn of the bilges and between the floor timbers using the garboard and top of the keel. The batteries for running your electrical equipment and starting the engine can probably be lowered several inches from their ordinary location. If your anchor is stowed on deck, get it below, under the floor boards if possible. There is no reason for small craft to carry anchor chain today. Your chain can be sold for the price of light nylon rope which will adequately do the job, be pleasanter

to handle, require no maintenance, and be considerably lighter in weight. If you have kept your bilges clean, they are the proper place for storing tinned food. Remove the paper labels from the tins and list the contents with wax crayon on the tin itself. Any and all weight which can be put under the floor boards gives you an important high-performance advantage.

Now consider the dinghy. Invaluable as it may be for cruising, its excess weight and windage are detriments to racing performance. A war-surplus inflatable raft is lighter, can be stored more readily, and is infinitely more safe as a rescue device. If the cost of such a raft is prohibitive in your area, sacrifice the dinghy altogether when racing and depend on life jackets.

### *Location of Weights Fore and Aft*

It is important to keep the bow and stern of the boat as light as possible. This gives them every opportunity to use their reserve buoyancy for climbing waves. The greater the length over which your buoyancy can be distributed, the smoother your boat will bridge the irregularities of the seas through which she is being driven. Structurally, too, it is important that great weights are not pressing in to drive against the slamming action of head-on seas. You will find that, by taking advantage of the natural shape of your boat from the cabin floor boards down to the bilge, the distribution of volume available for storage provides nice control for the balancing out of weight. Such items as anchor lines, pulley blocks, repair hardware, and extra batteries can be stowed here. Those items which might be damaged by bilge water should be wrapped in plastic bags to keep them dry.

## Trim

Trim is a description of the way your boat floats in the water compared to the way that her designer intended her to float. The term "trim" includes the amount of water the boat draws above or below her designed waterline, the angle her actual waterline makes with her designed waterline fore and aft, and the angle her actual waterline makes with her designed waterline port and starboard. When the boat designer created the plan of your boat, he had in mind the general distribution of weights that make up the total weight of the finished vessel. Minor variations in the weights of the materials used in constructing the boat, small variations in the builder's interpretation of the plans, making them different from the designer's concept, engine installations, and the variable factors of water and fuel proportions all combine to make the trim vary from the designer's original intention.

Fore and aft trim is exceedingly important in a small boat. The designer shaped the vessel so that water could flow from bow to stern along specifically determined lines. It is up to you to see that the boat trims out with people in the cockpit and a full load of equipment on board so that she is exactly parallel to her designed waterline. Whether your boat is a power



boat or sailing craft, if she has too much weight forward she will mush through the water, creating an area of great resistance ahead of her. If, on the contrary, she is high at the bow and trimmed heavy aft, she will drag a wall of water behind her which holds her back. The latter condition is by far the more dangerous of the two. A dragging stern can pull a following sea on board when the boat is being driven fast in heavy weather. Such an occurrence is referred to as "being pooped." It can be violent, crashing in the deck, filling the boat with water and sinking it. It is obvious that loading the boat until it floats below its designed waterline is a serious hazard to your safety at sea. Remember, too, that the small boat which floats absolutely level with her normal crew in the cockpit will appear to float down at the head when the crew has left. Actually, of course, the bow is trimmed just right and the stern is floating high. This may look unattractive at the mooring, but it will give you the fastest and most seaworthy boat conditions when you and the crew are sailing her.

### *Trimming with the Tanks*

Your water and fuel tanks can be used to a great deal of advantage in trimming your boat properly for racing. In light or normal weather, the tanks should be as nearly empty as is commensurate with safety at sea. This means you should have half a gallon of water per person per day in the water tanks, and just enough fuel in your gasoline or oil tanks to get you from the harbor mouth to your mooring. The fuel level, however, should never be so low that you cannot operate the engine when the boat is heeled or rolling. Remember, you may want to use the engine in heavy weather conditions to pick up a shipmate who is washed overboard. For races and long trips in which you have reason to suspect that the wind will blow predominantly from one side of the vessel, you can play the water and fuel tanks on that side to your advantage. When running under power for long distances in the trough of the sea, you should first exhaust the fuel on the lee or downwind side of the boat. By decreasing the weight in this tank first, you increase the boat's lateral stability to the rolling action of the sea. The same practice should be carried out with the water tank. In the auxiliary sailboat, it can be a good strategic gamble to fill only those tanks which you believe will be on your weather side for the greater part of the race. However, don't put yourself in an impossible situation by building what could become an unstable condition if the wind shifts or if you are obliged to turn back for some reason.

## Propellers

Whether your boat is a power craft or an auxiliary sailer, one of the most important features affecting her performance is the propeller. When the boat is being driven by its engine, the auxiliary sailboat's propeller is a

blessing, but when the boat is being driven by its sails, the propeller is a curse. It drags large quantities of water, slowing the boat down significantly, and seriously affecting the steering and handling characteristics. Arriving at a compromise situation, in which the propeller develops its greatest efficiency under power and is the least bother under sail, is a critical phase in tuning the auxiliary. Because many of the principles leading to propeller efficiency in both the power boat and the auxiliary overlap, we will begin with a discussion of the auxiliary sailboat's problems.

On the auxiliary sailboat the propeller should be as small as possible to reduce drag when the boat is driven by the wind. It should also work in a close-fitting, sharply faired aperture and the propeller never should have more than two blades. A two-bladed propeller working in such a structural arrangement can be so aligned that the blades lie in the plane of the keel or deadwood of the boat and create minimum drag. The propeller shaft can be marked in some conspicuous way, such as painting a mark which will be straight up when the propeller is lined up with the deadwood. Then you can rotate the shaft until the mark is in position and lock the propeller by putting the engine into gear. Never allow the propeller to rotate while the boat is under sail. Rotation not only increases the resistance of the propeller drag many times, but it also works extreme wear on the average gear box.

The shape of the propeller is very important, both in determining its efficiency under power and in reducing the amount of drag under sail. While the motorboat can get high efficiency and smooth operation from propeller blades which are approximately as wide as they are long, it is best in the auxiliary to sacrifice some in this area and cut down the propeller so that the blades are shaped in proportion, approximating those of an airplane propeller. Your propeller repairman can modify the blades in this way. As a result of such modification, you will find that you must operate the engine at a higher r.p.m. to get performance under power but this compromise is necessary to good performance under sail.

The alternative is to use a propeller with feathering blades, or a propeller of "clam shell" design. Propellers of this kind have movable blades which can be turned or folded in such a way as to present the least surface drag and profile drag to the water. While such propellers are very efficient in terms of blade drag, they usually have large hubs which may nullify any advantage you will get from reduction of blade geometry. There is no rule by which you can determine how much width of propeller blade you should cut away for optimum results. In general, a ratio for a single blade of three lengths to one width seems altogether satisfactory. It is important that you do not weaken the blade at its root near the hub in the cutting-away process. Tell your repairman to preserve full strength for each blade at the root.



On auxiliary sailboats which have offset propellers, that is, propellers which do not work in an aperture but emerge through the hull and operate below and to one side of the boat, the propeller should rotate so that the upper blades move inboard, toward the hull. This is because the bottom blades on the propeller are in denser water and are doing more work. Consequently, the thrust of the propeller which tries to head the boat toward the side away from it is counteracted by the sideways kick of the lower blade. On twin-screw motorboats, the bottom blades of the propellers should rotate toward one another. Again, you see, because the water is denser at the lower blades, greater thrust is developed. This thrust again is augmented by the approaching water from the lower blades.

One major reason for the inefficiency of outboard motors is propeller location. Because there is no boat extending above the propeller on the outboard, much of the water which escapes by centrifugal force from the blades is thrown upward instead of being driven aft. So-called cavitation plates are fitted by the outboard manufacturers to reduce this escaping water.

Cavitation plates are nothing more than sheets of metal which lie in a horizontal plane above the propeller, where they attempt to reproduce the hold-down effect that the hull of a boat with inboard power has upon the water over the propeller. It may be necessary, in order to develop the highest performance in your outboard-driven boat, to build an additional or extension cavitation plate which will be attached to the one already on the motor. Such a plate can be sawn from heavy-guage aluminum. The aluminum should be at least one-eighth of an inch thick, so that you can drill it and countersink it for flat-head machine screws. Use aluminum screws so there will be no electrolytic reaction and drill and tap into the cavitation plate already on the motor to receive them. Although the size of this cavitation plate can only be determined by experiment, you will find it wise to start with a plate which extends at least eight inches left, right and aft of the propeller.

The angle your motor makes with the transom of the boat is also an important influence on performance. You see, the blast from the propeller should travel as nearly parallel to the still surface of the water as possible. However, because the bow of the boat will rise when the boat is going forward at reasonable speed, the propeller blast tends to be directed somewhat downward. If you are really interested in high performance, you should experiment with the rake of the motor in relation to the transom. Frequently it is necessary that the original propeller blast be directed somewhat downward in order to get the boat to run level and true when at speed. As we pointed out in the chapter, "Testing the Boat," highest speed and greatest efficiency are obtained when the boat is running almost perfectly level, with the bow just slightly raised above the seas.

Sometimes on boats with inboard motors, it is possible and economical to move the propeller somewhat fore or aft along the initial line of shaft bearing. This is most easily done at the coupling end of the shaft where it is attached to the motor. Remember that it is always easiest to shorten the shaft and most difficult to lengthen it. Therefore, make no changes until you are certain that this is what you need. Should you wish to lengthen the shaft, an economical way to do so where there is a good clearance between the stern bearing and the coupling is to insert a block of filler material such as machined cast iron between the bases of the coupling. Be certain that the machining is accurate. It is a good idea in any case that the two faces or halves of the shaft-to-engine coupling be machined to fit one another accurately at the time the shaft or engine are installed in the boat.

### Rig

The first general principle in the tuning of the rig is to eliminate all unnecessary weight and windage. Careful study of the rig of your boat, as compared to the rig of other boats in action and rigging plans drawn by outstanding designers, will indicate where windage or weight can be reduced. For example, many boats today have several sets of spreaders on each mast. It is possible and normal to support the mast in quite a large boat with a single set of spreaders and this, indeed, is advantageous in every way. Any wire or pair of wires that you can eliminate from your rigging system is a saving of weight and windage at the same time and also reduces your maintenance problems with the boat. If, for example, your sailboat carries a single headsail rig at a height below the top of the mast, tension on the jibstay is usually obtained through backstays. These backstays are often paired and can be set up or slacked off on opposite tacks. With such a rig, a standing or permanent backstay which reaches from the top of the mast to the transom of the boat is altogether unnecessary and greatly reduces your efficiency to windward. Its only function, in fact, is to assist the mast in standing against breakage when carrying the spinnaker or when gybbing in violent weather conditions. For cruising then, such a rig has an advantage.

If you are an out-and-out racing enthusiast, however, you should be sailing your boat at maximum efficiency at all times. This means you can eliminate that back stay but there is no reason why you should not leave the fittings at mast and transom so that the wire can be reattached when you plan to cruise. A good alternative system when cruising shorthanded is to use your wire topping-lift, the line leading from the masthead to support the end of the boom. Once the mainsail has been hoisted, the topping-lift may be detached from the boom and a short, strong length of line led from its end to the transom. This will double in brass as a main-topmast backstay and is hooked again to the boom before lowering the mainsail. Such permanent backstays lie right in the area of maximum velocity of deflected wind from the close-haul mainsail and should, therefore, never be carried by the serious racing man.



There has been much discussion about the relative merits of rigid or flexible rigs. If you realize, however, that any springiness in your mast, shroud or overall rig condition acts in such a way as to absorb power of the wind, you will see at once that the more stiff your rig is, the more quickly and completely wind power is translated into boat driving power through a rigid system. This rigidity should not be obtained by high tension on the wire rigging of the boat. High tension in the wires against the mast creates a condition of great initial compression loading. This means that the total ability of the mast to withstand strain has already been yielded in part just to resisting the rigging. The amount of strength left available for resisting the loading of the sails is consequently reduced. It is therefore more valuable to make an accurate study of your mast when under load to locate those points at which it bends the most. Then, in the course of a season's racing, you can determine the proper location for repositioning of the rigging wires. While such an investment is unnecessary to the average cruising yachtsman, it is of vital importance to the racing man. Remember that if you think you need more wires you will have to buy them in any case. Consider first if the job cannot best be done by the new placement of a single wire which eliminates several already existing.

### Speed Indicators

While the speed of a boat over the ground can be determined very accurately by reference to fixed objects on the shore, by radio bearings, or by celestial navigation, the relative speed of a boat, that is, its speed through the water, is important to us from a standpoint of tuning. In this case, actual speed is not important. What we care about is the hull balance, engine revolutions, sail combinations, or trim which are most effectively driving the boat through the water. Distance-recording devices, such as the taffrail log can be used to indicate speed through the water by timing the run for a recorded distance. By the time this lengthy procedure has been carried out, conditions have usually changed so that the information is no longer valid. A continuous reading of relative speed, or speed through the water, may be obtained from several good devices on the market today.

The most effective continuous speed indicator is the Kenyon log manufactured by the Kenyon Instrument Company, Huntington, New York. This precision instrument measures changes in the water pressure against the sensitive hydraulically coupled finger which protrudes through the hull of the boat below the waterline. Speed and its fluctuations are indicated on a large dial graduated in a logarithmic progression and reading in tenths

of knots. Although this machine is exquisitely sensitive, its motion is damped by a hydraulic feedback system so that needle fluctuations are minimized. There is even an adjustment screw for zeroing the instrument and the dial is equipped with a light for night visibility.

Explicit directions are provided with the instrument for locating the strut or finger and every effort should be made to comply with these suggestions. The garboard area through which it is recommended that the strut be installed has been chosen because the flow of water along the planking here has the least turbulence. The strut itself should be securely set up by its retaining screw. This strut presents a problem with fouling by grass or barnacles; although painting it with a toxic finish affects the validity of the strut's registrations, the gain in convenience is worth the small loss in accuracy. Paint, you see, increases the profile drag and skin resistance of the strut so that the instrument acts through a slightly increased pressure which it interprets as increased speed. The reason we can tolerate this increase is that what we are really interested in is relative reading. We can state this in terms of performance by asking the Kenyon if we are going faster on this tack than on that, or with the boat trimmed one way in contrast to another.

Kenyon struts are designed so that they will break when struck by an underwater obstacle. This protects the mechanism itself from damage. The manufacturers tell you that it is easy to replace a strut from inside the boat by unfastening the mechanism from the hull and quickly plugging the hole. After you have installed a new strut, pull the plug, quickly replace the mechanism and reattach it. It is perfectly true that this can be done as just described. Unfortunately, in wooden boats, a few repetitions of this repair will generally strip out the threads from the screw holes. It is far better practice to ebb out the boat and replace the strut from the exterior.

Another hazard to Kenyon struts is the reaction of certain chemical bottom paints with the thin copper sheathing over the plastic core of the strut. Bottom paints containing a metallic toxin more noble than copper usually electrolyze the copper skin so that it cracks and bulges, leading to incorrect speed indication. Most plastic bottom paints do not produce this problem. It may be wise for you to use them on the Kenyon strut even if the rest of the bottom of the boat is protected by a different type of paint.

A Kenyon yacht log may be an investment of about two hundred dollars. The instrument is so far superior to any other speed indicator that it simply does not make sense to consider the alternatives. In top-level sailboat racing today, when distances are such that you may not be close enough to your competitors to know how well you are doing every moment, it is standard operating procedure to plot your courses by strategy and trim your sails by the Kenyon. On very large racing yachts, the instruments are generally used as a pair, one on either side of the boat. All this produces



is twice the expense and twice the resistance. Remember, you are only interested in relative speeds. The number on the dial does not matter so long as it is the highest number at which you can trim the boat to sail.

The serious racing man and the cruising boatowner really have much in common. Any gain in speed, performance or simplicity of operation of the boat is of significant aid to the fulfillment of their ends. This is so evident among long-distance racing craft that designers know that the best racer makes the best cruiser, the best cruiser the best racer. In distance racing, the comfort and well being of the crew as well as the safety and performance of the boat are inseparable from one another. In cruising, greater speed opens more harbors to you in a given amount of holiday time, efficient performance of the boat reduces the number of tacks, sail changes, and runs under power, which detract from the real pleasure of boating. Tuning, like genius, is the result of attention to every small detail and the consolidation of all aspects of the sport into an integrated whole.

## *CHECK LIST FOR TUNING THE BOAT*

### Trim

1. Boat should float at or above designed waterline.
2. Boat should float parallel to designed waterline when loaded with necessary equipment and crew.
3. Boat should have equal stability port and starboard when trimmed.
    a. Exception: when cruise or race is planned for sailboat where wind will be predominantly from one side, water and fuel tanks and food stowage on windward side should be of greater weight than on lee side.
4. Greatest amount of weight should be concentrated near center of boat instead of near ends.
5. Weight should be minimum weight necessary for trip.

### Stability

1. Save weight aloft.
    a. Reduce number of blocks.
    b. Reduce number of lines.
    c. Use stronger, thinner, lower weight lines.
2. Reduce wind resistance.
    a. Reduce number of shrouds and stays where possible.
    b. Eliminate flag halliards.
    c. Streamline spreaders and fittings where possible.
3. Keep weight low in the boat.
    a. Anchors and spare gear should be stowed below decks.

b. Anchor chain, tinned foods, and ballast should be stowed in bilges.
c. Locate water and fuel tanks as low as possible.

### Weight

1. Carry no gear which is not essential.
2. Substitute inflatable raft or dinghy.
3. Use light-weight plastic blocks.
4. Use light-weight plastic ropes.
5. Use light-weight modern anchors.
6. Carry minimum water and fuel with safety margins.
7. Use minimum crew.
8. If it is necessary to increase stability, do so by lowering ballast rather than by adding weight.
9. Use smallest, lightest engines.
10. Keep boat and bilges as dry as possible.
11. Substitute dry ice in icebox for water ice.

### Resistance

1. Keep hull smooth.
2. Fair all leading and trailing edges.
3. Use smooth, hard topside and bottom paints.
4. Keep bottom clean.
5. Check propeller alignment in aperture.
6. Cut down size of propeller if necessary.

### Propeller Efficiency

1. Propeller must run without vibration.
   a. Check alignment.
   b. Check propeller balance.
   c. Check propeller for damage from dents or pitting.
   d. Check propeller shaft bearing for smooth free operation.
2. Observe wake for signs of cavitation or rooster-tail.
3. Relocate propeller fore or aft, or use cavitation plate if necessary.
4. Experiment with small propellers and high r.p.m.
5. In twin-screw motorboats be sure bottom blades of propellers turn toward one another.
6. In auxiliary sailboats with off-set propellers be sure top blade turns toward hull.

CHAPTER 10

# Running the Boat

## CRUISING COASTAL WATERS

### Tides and Currents

Tide, used in its most general context, is the name given to the rise and fall of water along the coast lines of the world. It is for the most part a consequence of the moon's gravitational field working upon the mass of water, although other powerful factors such as the gravitational field of the sun, the inertial field of the earth's rotation, and the friction of the wind over the water's surface also exercise serious effects upon the tides. Predictions of the time and extent of the water's rise and fall are published in book form by the United States Hydrographic Office for every seacoast area of the world.

While tide is of little consequence to those who sail on lakes and rivers, it is a serious and constant consideration to those who run their boats along the coast. For them, the time and magnitude of tide can influence the length of a day's run, make a harbor inaccessible, or provide a tool with which to beach a boat.

The phases of the moon affect the tide. At new moon and when the moon is full, the tide is affected by the moon and sun together. Such tides are exceptionally high and exceptionally low. They are referred to as "spring" tides but the name has no relation to the season of the year. During the first and third quarters of the moon we have "neap" tides. At these times the sun is opposite the moon in its action upon the tide but the moon, having a greater gravitational pull, still draws the mass of water toward it to some extent. Neap tides show the smallest rise and fall above mean sea level.

Tidal current is the horizontal flow of local water which has been

poured against or sucked out from the coast and its irregularities by the gravitational forces of the moon and sun. Basic tidal currents are quite predictable. Tidal Current Charts are also published by the Hydrographic Office of the United States Department of Commerce. Such charts show diagrammatically, the direction and strength of the varying currents for their local area during every hour of the tidal change. Both the racing and the cruising man will find such charts invaluable. Learning to play the tidal currents can save hours on a day's projected run or carry you clear of dangers in the dark. Nondiagrammatic tables are also available in book form, published both by the United States Government and by several private concerns. Eldridge's *Tide and Pilot Book* is an old stand-by reference book for the New England coast. Sailors in that area will find it especially valuable because it condenses information, leaving out all data not pertinent to these waters.

While many more subtle influences, such as barometric pressure, wind direction and perigee and apogee of the moon in its orbit, affect the time, extent and direction of tides and tidal currents, some of these situations are unpredictable and can only be checked by on-the-spot observation. They are too complex to concern us here, and are not extensive enough to endanger the observant yachtsman. It should be noted, however, that in fog or other conditions where you don't have enough visibility to fix reference points, there is no quick, simple, accurate way to plot your drift through the water except by elaborate electronic equipment. Remember on the seacoast that tide and current are always present. Learn to recognize and observe them every time you sail. So long as you are on soundings with your boat, that is, in water less than one hundred fathoms deep, you must be prepared to compensate for the mass movement of the water through which you are sailing.

**Waves**

While waves of rivers are caused for the most part by the flow of water over the irregularities of the bottom and the river banks, waves of the sea and lakes are usually the result of wind. Friction of the air passing over the top of the water drags small areas of the surface into irregularities. These irregularities trap more wind in turn, and also deflect some of the flowing air downward. The two effects combined cause even larger waves. If the velocity of the wind is constant, equilibrium is soon reached. If the wind is gusty or changing in direction, the waves may build one upon the other or cancel one another out. If the wind continues to increase in strength and blows from the same direction for a long enough period of time some majestic wave fronts will develop. In the dead of winter, when the wind has great mass and velocity because of its heavy load of water vapor, a gale wind on the open sea can raise waves more than forty feet



high from trough to crest. The longest ocean waves recorded were twenty-six hundred feet in horizontal length and attained a speed of nearly sixty-eight knots. In exceptional storms, such as hurricanes, it is possible for breaking waves to rise to a height of one hundred feet. Encountering such a wave would involve extraordinary bad luck and, in any case, such a meeting is not recommended to small-craft sailors.

**Breakers**

In deep-sea conditions where wave propagation is relatively undisturbed, breaking crests are predominately the result of wind velocity. There are certain mathematical relationships which determine the height to which a mass of water can be piled before it becomes unstable. Also, the wind can drive the small-volume top of a large wave at much greater speed than it can move the larger-volume base of that wave. When this condition occurs, the wave top simply tumbles over and forms a whitecap.

Now even when wind conditions are very light, a wave approaching obstacles such as shallow water or rocks will have its speed retarded at its base. Inertia of the top of the wave again carries it ahead of the base and the water tumbles in a whitecap. This situation is referred to as "breakers" or "surf." It is a particularly useful signal to the sailor who is approaching a coast for which he has no chart or who is making his landfall in conditions of low visibility. The sound of such surf alone will be taken as a warning long before the seas themselves are perceived. An understanding of this phenomenon will enable you to locate passages and channels through obstructed areas. Simply remember that where the wave formation is the gentlest and whitecaps are not seen, there is the smoothest water and consequently the deepest. When you have developed experience in detecting the pattern made by these smooth areas, you will be able to safely negotiate reef areas anywhere in the world. It is important to recognize, however, that in very calm weather, breakers may not form but the reefs will still be there.

When the tide is moving against the direction of the wind, the relative velocity of the wind across the water is greatly increased. This condition is usually accentuated at harbor mouths and other constricted areas. It is at its worst at river estuaries when there is an on-shore wind and a rapidly falling tide. Very dangerous seas can build up during such conditions and they are hardest to perceive from offshore. In extreme cases it may be necessary to cruise about at a safe distance from the shore until the tide or wind has changed.

If you must run your boat through breakers, particularly those coming from the direction of your stern, do so at your lowest possible speed. A useful safety device in these conditions is a long length of heavy rope. A rope of one hundred feet is not too long. Secure the ends to either side

of the transom of your boat and let the loop drag in the water to slow you down. In a real emergency, dragging mattresses behind or capsizing the dinghy to swamp it and towing it on a long painter are excellent breaking devices. You see, the tumbling water on the advancing face near the top of such waves has great velocity and may be quite variable in its direction. Like the feathers on an arrow, the resistance which you tow astern lets your boat, which is equivalent to the heavy head of the arrow, correct itself against an opposing force. If you make the mistake of trying to race faster than the waves you may be spun out of control and roll over and swamp. In serious storms along the coast, breakers are the greatest hazard you must face. It is always safer in extremely rough weather to move out to sea. The waves are gentler there and until the weather moderates the greatest danger you will be in is that of acute discomfort. Remember that your boat was designed and built to live upon the sea. Remember, too, that waves don't hurt a boat, the boat just hurts itself. Consequently, if you have ample room in which to drift and your boat is under no way of her own, she is in minimal danger from her environment.

### Wind

Wind as the sailor knows it is a horizontal movement of air across the surface of the earth and sea. The primary cause of this movement is the variation in temperatures of adjacent spots of the earth. When the sun heats the air, this air expands and rises. Cooler air from the surroundings rushes in to fill the space the rising warm air has left. This we refer to as "wind." Friction from the earth's rotation, deflection of the air in motion by geographic obstacles, and the phenomenon of gyroscopic precession influence the direction of the wind's travel. The wind also moves in large vertical convection currents and these, together with the foregoing influences, create great bands or regions of prevailing winds about the earth. For each locale, prevailing wind conditions follow uniform patterns during each season of the year. When these patterns are interrupted by squall or storm conditions the new or superimposed pattern generally follows a regular series of events. The United States Hydrographic Office publishes weather charts showing surface winds and currents for different seasons of the year. These pilot charts diagrammatically show the percentages, directions and strength of winds, storms and currents for each five-degree square of the map. In addition, on each is written the probable incidence of fog and ice and the expected range of temperatures and barometric pressure. For example, tô the sailor on the eastern seaboard of the United States, the pilot charts of the North Atlantic Ocean are invaluable reference guides.



Because of its mass and specific heat, the temperature of the sea changes very slowly and only slightly during each day. The temperature of the earth, on the other hand, varies rather quickly. During the day, reflected sunlight from the earth plus heat radiation along the ground yield a higher temperature to the surrounding air more quickly than sunlight on the sea. This rising air is replaced by air coming in from the water area and the breeze blows mainly toward the shore. At night the situation may reverse. The land cooling quickly provides heavy air to replace that air rising from the now warm surface of the water. We say, then, that we have sea breeze in the daytime and land breeze in the night. When other wind conditions are more dominant, such as the trade winds which build their force over many miles of travel, the local conditions are subdued or overwhelmed. The sailor must study the patterns and habits for the areas in which he sails so he can combine the effects of wind and tides and play them to his advantage. The power of the wind can increase the velocity and magnitude of the tide or cancel it altogether for a time. By careful observation, coupled with regular barometer readings, your weather predictions will become entirely dependable.

### Barometers

The barometer is an instrument which measures and indicates atmospheric pressure. The trend, or pattern, which variations in barometric pressure follow can be used to forecast general weather conditions. The ordinary legends on the face saying "stormy," "rain" and "change" are meaningless when taken at their word. Barometric readings should be taken at regular intervals and interpreted as trends. In general in the United States, certain wind and barometric trends indicate specific weather. The speed and extent of barometric changes are good indications of the severity of the approaching weather and the speed at which it is approaching. Here is a table of general barometric trends and their meanings, correlated with wind direction for the United States.

Wind north to east, barometer at 29.80 and falling—severe northeast gale.

Wind northeast to east, barometer at 30.10 and falling—rain and wind within twenty-four hours.

Wind northeast to east, barometer at 30.10 falling slowly—light winds and rain in several days.

Wind northeast to southeast, barometer at 30.10 falling slowly—rain without much wind.

Wind northeast to southeast, barometer at 30.10 falling rapidly—rain with increasing winds.

Wind east to south, barometer at 29.80 falling rapidly—severe storm imminent.

Wind south to southwest, barometer at 30.00 rising slowly—clearing and fair.

Wind southwest to northwest, barometer at 30.10 stationary or rising steadily—fair weather for several days.

Whether rising or falling, any rapid large change in barometric pressure can be a warning of strong winds.

### Fronts

Major weather changes move in a general west to easterly direction and visually announce their arrival by the presence of their fronts. These fronts are the cloud formations at the meeting layer of different weather conditions. When two different fronts collide or meet with one another the warmer one will override the colder. Often this line of interception is marked by a distinct cloud pattern which helps us recognize the passing front, and identify it as warm or cold.

The coming of a warm front is usually presaged by a few feathery cirrus clouds followed by a thick gauze of stratus clouds and finally by cottony cumulus clouds at the lowest level. One form of the cirrus cloud is known as the "mare's tail." It is a time-honored sign of approaching bad weather and clockwise veering winds.

The cold front approaches more dramatically. It leads in with a powerful squall line of dark rising clouds. Temperature drops quickly and the barometer may even rise. The wind will often veer rapidly and have great force. Such wind is rarely of long duration. Within a short time it usually has passed and heavy rain comes down.

### Thundersqualls

Isolated thunderstorms can be easily avoided by the small-boat sailor and he will be well advised to do so. Hazards of thunderstorms include wind, rain, lightning, hail and, on occasion, waterspouts. These storms tend to move at speeds of less than twenty miles an hour and they travel in a general easterly direction. The typical configuration of a thunderstorm is called an "anvil head." As its name would indicate, it is a large horizontal anvil-shaped top formed on a cumulo-nimbus cloud and is an indication of the great turbulence of air within the storm.

If you can't avoid a thunderstorm, lower all your sail and attach a length of chain or heavy wire from which the insulation has been scraped to the shroud or stay reaching highest on your mast. This wire should trail in the water to ground out static electricity which may attract lightning. The largest wire you can find is none too big. It is wise to carry on board a length of chain for this purpose, fitted with a large metal snap hook which can be quickly affixed to a shroud or stay. When caught in such a storm, and if your proximity to land permits it, choose a downwind course which will most quickly get you clear of the storm area. (There is much folklore concerning waterspouts, including the myth that a waterspout can be dispersed or broken up by loud noises or by gunfire.) Wind velocity in waterspouts has been estimated at speeds up to five hundred miles per hour. Since winds at sixty miles an hour are classified as hurricanes, it seems more logical to flee than to stand and fight.



### Hurricanes

Although hurricanes are referred to as tropical storms they may be encountered anywhere in the world. They are circular in form with the wind blowing counterclockwise in the northern hemisphere and clockwise in the southern. The wind converges upon the storm at an angle of about thirty degrees. Thus, if you face into the wind in an approaching storm, the storm center will be about one hundred and twenty degrees to your right in the northern hemisphere. These storms ordinarily continuously deflect to the right of their path of progression in the northern hemisphere and to the left in the southern. Certain quadrants of the storm are referred to as safe and others as unsafe. A quadrant is literally the quarter of the arc of a circle. It is a sector extending through ninety degrees and, in terms of the compass card, the four principal quadrants are: north through east; east through south; south through west; west through north. The safe quadrant in the northern hemisphere is to the left of the path along which the storm is advancing. In this quadrant the wind will tend to blow you away from the center of the storm. If you are caught at sea in hurricane conditions you should crowd all speed, so long as it is safe, to remove yourself from the path of the storm.

Storms have their own personalities but there are certain indications from which their presence can usually be deduced. In deep water the swell of the storm often extends for several hundred miles ahead of the storm itself. This swell will be recognized as an enormous rolling underlayer of waves whose passage completely ignores the already existing wind waves. The direction from which the swell is coming is some indication of the direction that the storm was when the swell was generated. Lurid colors at sunrise and sunset often make dramatic skies before the storm. Long strips of cirrus clouds seem to radiate from the storm's center. These strips begin to thicken, forming a layer of stratus. During this time the barometer begins to drop. As the rate of barometer fall increases, dark low clouds begin to form and soon the sky leaves no doubt in the sailor's mind of the severity of the disturbance. Some small craft have lived through hurricanes at sea but the odds are very much against it.

In harbor, preparations for a hurricane should include the following steps:

All sails, oars, dinghies, and general deck gear about the boat should be stowed ashore or low inside the boat.

Two or more of your largest anchors should be set on the longest nylon rope available. If swinging room permits, several hundred feet of line are none too much.

If you know a deep harbor sheltered by high land on all sides, go to it. Densely wooded areas and narrow rivers generally provide good wind protection.

All doors and hatches must be securely closed.

Scuppers and self-bailers should be clear and free of all obstruction.

Booms and spars must be securely lashed to the strongest fittings on the boat.

On sailboats, one or more of the anchor lines should be fastened to the mast down near the deck.

Ample chafing gear should be provided for all anchor or mooring lines.

Gusty cross winds may heel the boat far over before it has a chance to head around to a comfortable position. Be sure no gear can come adrift to weight the boat on its lee side or thrash about and do damage from inside.

Lightning often accompanies hurricanes. Provide an ample rigging ground deep into the water.

Close all sea cocks so that, in the event of a knockdown or swamping, water cannot flow back into the boat.

Close the exhaust-pipe valve or securely plug the end of the pipe.

### Fog

Though not as dramatic as a hurricane, fog can be entertaining enough in its own right. It is responsible for the purchase of more radio direction finders than all the electronics salesmen put together. Fog is a condition of air in which water vapor has been cooled to the dew point and it may occur in daylight or at night. Daytime fog generally burns off while the sun is near its zenith. Night fog may endure throughout the entire period of darkness and well into the day. In the northern latitudes, during some seasons, days and nights of continuous fog bring surface traffic to a standstill.

In areas such as the tropic seas, fog is almost entirely unknown. The sailor is imbued with a strong sense of security because he continuously operates in good visual navigation conditions. Then, when loss of visibility from fog or rain occurs, the sailor may be caught without a sufficiently accurate plot of his position to be able to lay a useful course to safety.



In any waters, normal safety precautions include knowing your position at all times so accurately that you can immediately plot it on your chart, analyze it in relation to your course, and chart its dangers. If fog catches you unawares and you do not know your position, your only safe procedures are either to anchor and wait for clear weather or to run off shore far enough to be safe from outlying dangers, then to continue, at a safe distance from shore, until you reach a fog-free harbor.

When it is essential to travel in fog, the sailor must correctly use his knowledge of tides and currents, must accurately know the speed his boat makes through the water, and must have a properly compensated compass for which he has correctly computed the local magnetic variation. While the compass will be discussed under its separate heading, here is a list of pointers for safe navigation during fog.

1. Operate at a slow, constant, accurately known speed if possible.
2. Station at least one person right in the bow of the boat and another one as high as possible.
3. Use your fog signal.
4. Keep your estimated position plotted at all times.
5. When running from buoy to buoy, if you miss one marker by the end of your elapsed time for its run, turn onto your new course as though the missing marker had actually been spotted. If, at the end of the next elapsed run, you don't spot the subsequent buoy for which you have been seeking assume that you are lost. You must then either run offshore to seek safe water until the fog lifts or anchor in that spot and keep your fog signal going.

Identification of sounds and their direction can be deceiving in a fog. Always anchor your vessel when in doubt. Inexperienced seamen often trust their instinct at the expense of their compass. Contrary to popular belief, instruments do not go berserk. Passenger air lines, passenger steamships and military vehicles may be forced to make landfall in adverse conditions. They do this routinely by instruments. A pilot or captain who relies upon his instinct is headed for trouble.

### Maneuvering

Manuevering can only be learned by experience because it involves the same kinesthetic sense which tells you how hard to throw a ball or how much strength you must exert to jump from your boat up to a dock. Whether you are handling a boat, driving a car, or flying an aircraft, this kinesthetic sense must be developed and must become automatic. In this section, then, all that will be offered are suggestions for maneuvers you must practice over and over again.

For the sailor or powerboat man alike, judging the distance a boat will drift when swung into the wind and sea is of primary importance. The

sailboat man must learn this maneuver for he will use it in every landing he makes. It is also essential to the powerboat man who should always operate his boat with a drift allowance that provides him with adequate safety if his engine should fail. In rough sea conditions, the sailboat man may be unable to come about to the opposite tack unless he sails the boat off a bit to pick up sufficient residual speed so that his inertia can carry him against wind resistance and the stopping action of the waves. The best place to practice these maneuvers is in open water, using an anchor buoy or float for a target. With a little experience you will quickly learn to make approaches that are nearly perfect. Don't lose patience with this practice. It is not only a normal docking and mooring maneuver but is an operation you may have to use in effecting a rescue. Perform these approaches into the wind, across wind, downwind, as well as close-hauled positions until you do them by reflex. They are the most important of the fundamentals.

The motorboat man should practice making use of torque. In the chapter, "Tuning the Boat," we speak of the self-steering qualities which can be obtained by counteracting the torque of the propeller by offsetting the engine. When the boat has little way and you operate the propeller during short intervals for docking, there is not time for the propeller to develop enough slipstream to overcome its torque. Now, the usual deep-bowed motorboat which is being maneuvered in this manner has very little side reaction up forward. Aft, at the stern, the amount of swing from torque and rudder control is relatively great. Through practice you will quickly learn which way each propeller kicks the stern and in close quarters you will be able to do much of your maneuvering by the use of the clutch levers alone.

At low speeds all boats are difficult to steer in reverse. The propeller slipstream is not deflected by the rudder, so you have no initial steerability. For this reason, in sail or powerboats, you should depend on getting all your directional control during the times of forward thrust when docking. Your reverse gear can be used to pivot one propeller against the other in a twin-engine boat but in a boat with one propeller consider your reverse to be useful only for gaining room forward, or for checking the way of the boat.

In very shallow auxiliary sailboats, you will have to experiment with the centerboard to find what position provides you with the easiest handling characteristics under power. Centerboard-keel auxiliaries generally handle best when the board is hauled up all the way. In sloops and yawls and ketches the wind resistance of the mainmast will usually try to throw the bow around on a cross wind approach. Advantage can sometimes be taken of this to sidle your way into a tight docking area by pulling your helm hard over as though you were going to head dead to windward but



only working your propeller in short bursts forward. The resultant motion will be a series of arcs with a net effect of motion to one side.

When the wind and tide are at variant angles to one another, you should stop the boat in a clear area well away from your mooring. Lie at an angle parallel to what will be your final approach and see which way the boat is set. You can tell at once whether the wind or the tide has the greater effect. You should then go about your mooring, treating the problem as though only one force were working against the boat. This will be a composite of the wind and tide forces and, by treating them as one, you greatly simplify your problem.

In a strong cross wind or cross tide you may find it possible to make a perfect approach to the dock but impossible to hold the boat there long enough to get out lines. Under these conditions it is usually possible to warp the boat into place alongside the dock by applying power to force the boat in by a single rope. This rope should be used as a spring line. Make one end fast to a stout cleat or winch in the midship area of the boat. The other end should be made up so it can be quickly secured on the dock. Then, at slow speed, with the boat held parallel to the dock, you can angle her into place.

**Anchoring**

Anchoring is an art which has so many ramifications that it cannot be reduced to a science with step by step procedures. Fundamentally, however, anchoring consists in making the small weight at one end of the anchor line restrain the great weight at the other end. We can see that, to do this, the most important factor is the ability of the anchor to dig in and hold. Except for freak conditions where the fluke of the anchor engages in a rock crevasse the points of the anchor must be strong and sharp to do their work. The best of the traditional "yachtmen's kedge" anchors were made by the Herreshoff Manufacturing Company. It is still possible to pick these anchors up at second hand and they are among the best investments you can make. Hand forged and galvanized, these anchors are non-fouling and hold like the proverbial hinges of hell.

The best of the modern lightweight anchors are the Benson and the Danforth. A variation of these anchors, manufactured by Rosselle's Metal Works, Miami, Florida, has an improved version of attaching the anchor rope which facilitates breaking out the anchor if it becames jammed on the bottom. The greatest advantage of these lightweight anchors is that they can be carried flat and do not need to be assembled or set up for use. When cruising waters such as the Intracoastal Waterway, where drawbridges and other hazards may make emergency anchoring necessary, this type of equipment can be carried on the afterdeck of the boat attached to a coil of lightweight line such as nylon. Make fast the terminal end of

the line to your strongest cleat or sampson post so that if you must let go of the anchor without warning everything is in readiness.

Because anchors can get fouled by underwater obstructions, it is customary to rig a tripping line at the T formed by the shank and fluke of kedge anchors and lay this line loosely along the anchor rode itself, making it fast at a height which you can easily reach from deck. With this arrangement, if it should be impossible to break your anchor out by normal vertical hauling, detach the upper end of the trip line from the anchor rode and, after making the trip line fast on deck, slack the rode and ease the boat forward, under power. This action will drag the anchor opposite to the direction in which its flukes work and will generally free it from any obstructions at once. If fouling is so serious that you must cut the anchor rode and leave the anchor on the bottom, attach a marker to the trip line so that you can locate the anchor again and go after it with a more powerful boat or with Scuba (self-contained underwater breathing apparatus) equipment. A buoyant cushion will make a convenient, easily visible buoy.

A major reason for the preference of nylon for anchor rope is its ability to stretch and absorb some of the shocks delivered by the boat before they reach the anchor. By so cushioning these shocks, you greatly reduce the tendency of the anchor to break itself clear of the bottom. For this reason, too, you should always anchor to the longest rode which swinging space permits. The longer the rope you use the more gradual its angle upward from the anchor. The addition of a fathom or more of chain between the anchor and the rope attachment will help to cushion the shock and, moreover, will greatly reduce the damage from chafe upon the anchor rope. This is particularly important when cruising rocky-bottomed waters where a short time period of chafe might endanger your boat. Your chain need not be very strong to have a cushioning effect on the entire length of rope against which the weight of the water is reacting.

A safe and convenient guide to link thickness is the diameter of the pin which acts as a clevis between the shackle and the anchor. The chain is also in a position of great mechanical advantage so that its weight has a significant value in cushioning the shocks delivered by the boat. In very heavy weather the addition of a weight about half way down the anchor line is especially good protection against the anchor dragging. A special saddle is available which hinges over the anchor rode to carry such a weight. The saddle is lowered by a check line from the boat and any object of sufficient mass, such as the lead from your sounding line, will act as a buffer. A "Rode Rider" is available from Dorham, The Bosun's Locker, Box 212, Noroton Heights, Connecticut. This device is also recommended for use on the dinghy painter for towing in following seas.

In tideways or fluky wind conditions the boat may circle its anchor without putting sufficient strain on the rode to keep it from wrapping about



the stock or flukes and fouling. The flat, modern anchors are best in these conditions but particular attention must be paid to the Benson anchor. The very design of the shank which makes it easy to clear from obstructions is a hazard here, when the direction of pull against the anchor is easily reversed. The Danforth and the Rosselle anchors are entirely free from this danger. Under these conditions a conventional kedge anchor may be protected from fouling if you attach a buoyant device to the anchor rode at a point just beyond where it would break the surface of the water if pulled vertically over the anchor at high tide. Such a device should be just buoyant enough to float the rope. A cushion, a discarded life jacket, or a scrap of cork is adequate for this job.

In very heavy weather two or more anchors may be streamed from the bow of the boat to share the load. These anchors should be laid so that their rodes form a V of about thirty degrees. If the anchors are of unequal weight put the lightest anchor on the longest rode. You can set this anchor first, drift back on the line for a distance of about three times the depth of the water at high tide, then move off at an angle of about thirty degrees and set the heavier anchor. Remember that the total length of the shortest rode should be at least three times the depth of high water. This is an absolute minimum and the more scope you get beyond this minimum, the better.

The mushroom anchor is the most satisfactory anchor for permanent mooring. A "Table of Weights" for mushroom anchors is given in the Appendix, proportioned for cruising auxiliary sailboats. This type of boat was chosen because it is generally of greater weight and wind resistance for its over-all length than any other type. If your boat is particularly heavy or exposed to unusual wind and sea conditions you will be wise to consider using a pair of mushroom anchors, each of which can be one size smaller than the recommendations in the table.

In any case, mooring anchors should be rigged to chain at least as long as three times the depth of the high water. Be sure this chain is secured to the anchors with shackles which have their pins securely wired in place. Use a noncorrosive wire and carefully examine the coupling each season. A flexible stainless-steel wire can lead from the chain to the mooring float. This wire should be machine spliced at both ends, the end which is shackled to the chain being fitted with a stout thimble, and the eye which will secure the boat being padded with rawhide. The float for picking up the wire pennant is usually attached to the pennant by a small-diameter nylon line. The best floats are those fiberglass-covered light-weight units with a three or four foot flexible fiberglass ball-tipped rod by which you pick them up. These can be painted so that they are luminous to your searchlight after dark. They are particularly safe to handle and obviate the danger associated with broken boathooks when you try to catch the mooring, under way.

Whatever mooring system you use, be certain that proper chafing gear protects the line at the chocks. A solid length of polyethylene hose, large enough in outside diameter so it can be wedged in the chock by its own elasticity, is the handiest device. It should be not less than eighteen inches long and, if you use it on a mooring line which always attaches to the same length, the hose can be lashed in place with marlin or plastic electrical tape. Tape, canvas, or a wrapping of string or twine all give sufficient chafe protection if plastic hose is not available.

## The Compass

Next to an ample supply of food and fresh water on your boat, the most important piece of equipment you can carry is your compass. The entire earth is a magnet surrounding itself with a field in which your compass reacts. However, because the magnetic poles, one in each hemisphere, are not coincident to the geographic poles, the north and south that the compass needle indicates vary from the true direction according to the compass's geographic locality. This angle of difference is called "variation." There are also progressive changes of variation which occur with time. Navigational charts indicate the variation in the geographical zone they represent and state the annual change of variation by which you can correct direction to bring it up to date since the year the chart was published.

Besides the error of variation, the compass must also be corrected for deviation. Deviation is the deflection from the magnetic north due to various attractions in the boat itself. A deviation card should be made for your compass to determine its error at each point of the card or if the compass rose is graduated in degrees, at each fifteen-degree interval. These deviations are best determined by running headings on ranges or conspicuous landmarks that you have plotted from the chart. You must remember, however, to check the boat's compass readings against the chart readings corrected for local variation. The compass readings, then, will be different from the magnetic readings of the objects on the chart by a given number of degrees on each heading. This number of degrees is the deviation for that heading of your compass.

A number of fine small-boat compasses are available at low prices today with built-in compensating magnets. Compensating magnets are small magnets which lie below or around the compass needle. These magnets can be moved by adjustment screws so that they have more or less effect on the compass needle, enabling you to correct the compass error and to minimize it until the compass agrees with the direction of magnetic north indicated on your chart. Adjustment of these compensating magnets enables you to reduce the extent of deviation to a negligible amount. Such arrangements of magnets can also be purchased for attachment to compasses not already fitted with them. Although it is possible to correct your deviation by locating several bar magnets at distances about the compass, correction by this method is complicated and, in small craft, obsolete. Most of the deviation corrective units are turned or adjusted by machine screws. It is imperative in correcting a compass that you adjust these screws only with a nonferrous screwdriver. A suitable one for this purpose can be made by filing a blade edge on one end of a short length of brass rod.



Once your compass is adjusted for deviation of the boat, the correction will be valid for a considerable period of time. When you lay up your boat or make a radical change in your locale you will require additional compensation. Under no circumstances should you ever compensate your compass for local variations. This correction should only be made in your log book and on the chart. Local variations change from area to area as you cruise and the danger in correcting your compass for each of these changes is that you may lose track of the locale for which your compass has been adjusted. Courses plotted to include such errors will have no validity and you may run your boat into danger.

As we pointed out, compasses do not go berserk at night or in the presence of fog. However, they do react emotionally to can openers, jackknives, screwdrivers and electric wires. An old shipmate of mine with a penchant for chrome-plated large steel cowboy buckles used to wonder why north always seemed to lie in the region of his navel and why he spent so much time aground. Parallel electric wires cause compass errors, but if electric wires are twisted about one another their magnetic fields are cancelled and no longer will affect the compass.

Liquid-filled internally gimballed compasses with built-in illumination and cards at least three and one-half inches in diameter are the minimum requirements for satisfactory navigation of small craft. Great care should be taken in the installation of the compass to ascertain that the lubber line, or reference point, lies in a true fore and aft direction on the boat. A convenient way to check this is to stretch a tight string from the stem to the center of the transom and to make sure the lubber line is parallel to it. Eye strain is greatly reduced when steeering compass courses if the dial is calibrated at intervals of five degrees. This is closer than any helmsman can steer a small boat in rough conditions. To further facilitate compass steering, choose a card with contrasting numbers and background. Most experienced sailors prefer white numbers on a black compass card. Locate the compass far enough ahead of your steering position so you see the lubber line across the card rather than down upon it. If the compass will be installed in the open cockpit of the boat, provide it with a polished metal or a white fabric cover to protect its plastic dome when not in use.

## Depth of Water

While there is scarcely a body of water in the world today for which

accurate navigational charts are not available, the ability to judge the depth of water can be vital to your safety when your position is unsure or visibility is low. In the first section of this chapter we discussed the warning given by breakers or surf. A more dependable indication of shoaling water is the leadline. While any weight great enough to carry a piece of string to the bottom will give you an indication of the depth, a more refined sounding line can tell you several other things. For the small-craft sailor, a ten-fathom length of rope attached to a three-pound lead should be adequate for normal use. At one-fathom intervals, measured to the bottom of the lead, you should attach markers which give visual indication of the depth by day and which you can read by feel with your fingers in the dark. You can, for example, mark the first fathom with a bit of leather thong. The second fathom can be a patch of smooth fabric such as nylon. The third fathom can be another thong, this time with a knot in it. The important thing is that you can tell at once how much water is beneath your boat. The lead itself must be heavy enough so it can be thrown against a strong wind and still have inertia to carry the length of rope behind it. It must also have weight to keep it straight in a tideway. There, you can use it lowered straightaway from the side of your boat to detect whether or not you are dragging anchor. The same tactics can be employed when the current is unknown and you are moving through a fog. The leadline will tell you at once if you are progressing over the bottom or only through the water. If the line streams aft when the lead is touching bottom, you are under way.

The base of the lead is generally cupped or hollowed. In this area you can rub a bit of tallow or soap to "arm" the lead. The lead will gather samples from the bottom which you can check against the markings on the chart to help determine your locale. In some areas there are distinct changes across the bottom of the sea. Where a river drains the bottom may be mud. At one side of your harbor the bottom may be fine shell. The bottom at the opposite shore perhaps is kelp or stone. Checking several casts of the lead to get an average of the bottom directly beneath you is an important way of using the leadline.

A second important use of the line in checking your position on the chart is to record specific depths of water at one dozen or so even intervals along your run. If you mark these recorded depths on a piece of tracing paper, scaling the interval between them to match the distances on your chart, you can often obtain an accurate position. The trick is to slide the tracing paper about on the chart in the region you believe you are sailing until the pattern of depth changes matches the findings of the Hydrographic Office. Notice that word "pattern." It is improbable that your soundings will be taken at mean low water as those were on the chart. But if the difference between the chart soundings and those you plot on the tracing paper remains constant and the direction or vectors along which they were taken is the same you can make a highly educated guess concerning your position.



Some useful general deductions concerning the depth of the water can be made from observation of the land and its contours. In rivers, for example, the water is usually deepest along the bank which has the greatest radius of curvature, that is, the most gradual arc. The velocity of the water is generally greatest here and scours away the most bottom. Along the coasts of large bodies of water, the depth is often correlated with the height of land. Generally speaking, a steeply rising coast has a sharply graded bottom and gentle sandy shores continue their shoals far out to sea. Color of the water can be used in many places as indication of the depth. Along the southern coast of the United States, the Bahamas and West Indies, Lower California and the Gulf of Mexico the waters are remarkably clear. Deep colors here indicate deep water and the softer pastel shades show moderate depth when they are on the cool side of the spectrum; that is, blues and greens. When these colors go to yellow and brown the water is very shoal. Along the northern coast and most rivers and lakes, yellows and browns are the only color differentials that we see. By the time they appear in these darker waters you are well within the danger zone. Therefore, in regions where the bottom cannot normally be seen, greater caution should be used in determining the depth. With the chart and buoy system of today there is no excuse for moving into danger with your boat.

**Running Aground**

While this section should be more properly termed "Getting Off," sometimes you can't get off at all. Fortunately, however, most groundings are petty things and those of us who cruise in shallow water soon learn to take them in our stride.

The most important thing to know when you touch bottom is the condition of the tide. If the tide is rising you have time to think. If it is falling you must act at once or risk a delay which may last twelve hours. If you touch when under sail, often you can heel the boat so that she draws less water and slide her off again. If you touch with an on-shore wind, however, drop your sails at once and go to work. A stout oar, a spinnaker boom or the mast from your dinghy may suffice to push the bow around. Most boats have a pivot point somewhere behind the bow and, if you can't back the boat straight off the way she came aground, heading her around will often do the trick.

If you do not get immediate action from these attempts, get an anchor out to deep water as far as you can and as quickly as you can. If you have a dinghy on board, attach the longest line that you have to the anchor and

row it out with the dinghy, dropping it in deep water. Now, very gently until the anchor has dug in, take up the slack in the line and see if the boat will start to move. The combination of pull on the anchor line, use of the engine, and pushing from forward may be sufficient to get you under way. If you still stay hard aground and your boat has a sturdy mast, rig a pulley so the anchor line will deliver its load up high. You can take up the slack of the anchor line from the deck but the pulley lead on the mast will heel the boat to make it draw less water and it will also exert tremendous leverage. If this trick combined with the aids of power and pushing won't get you off, you may have to remain in waiting for the tide.

Before you settle down to that long vigil, consider making the boat lighter by putting everyone in the dinghy or on the beach. Sometimes just by changing their position on the deck they will vary the angle of floatation of the boat which, in turn, may break any suction from the mud which is restraining her in place. If, in the end, you must settle down to wait there are some important precautions you must take. The first of these is to put enough initial tension on the anchor leading to deep water so that any motion of the boat from incoming seas or tides will let that tension start to pull her off. Remember that by the time the tide comes in again the weather may be different. If you went aground when waves were running, your boat may already be in serious shape from pounding. In any case you must prepare for this as well as you are able. Lighten the boat as much as possible at the first sign of increasing waves. Remember that the less she weighs the smaller the force the pounding can exert. Close all through-hull openings except the cockpit drain. A boat which is heeled on her side may start to syphon water before she rights. Be certain that all your port-holes have been closed and that your hatches are well secured.

Should you decide that you are in real danger from pounding and the sea, take your cabin mattresses and try to work them into position beneath the low side of the hull before the tide permits the planking of your boat to touch the land. Lash these mattresses in place as well as you can. If the shore is rocky, you might seriously consider sacrificing your dinghy to cushion the hull of the large boat from the shore. However, if such an action would jeopardize your life, your only intelligent move is to leave your boat and wait on shore until you see how she fares. Deserting the boat should only be a last measure. The chances are that when the tide returns she'll float out without a scratch. Once you desert her, you no longer have any protection against public salvage. The important thing is to remain calm so that you can properly evaluate the situation.

**Emergency Repair of Punctured Hull**

There is a simple standard procedure of first aid for a staved-in boat. This is called the "soft patch," and is exactly what its name implies. If you



somehow punch a hole through your boat, it may be very difficult to plug it from the inside. Water exerts tremendous pressure and the logical thing is to take advantage of this and make it hold a patch against the outside of the boat. A sail, a mattress, an awning, or a rubber raft can be quickly thrust over the damaged area. The in-pouring of water through the hull will help direct the soft patch to the wound. Once it is in place it will usually remain there by itself. However, to be doubly safe, you should secure the patch by lines run right around the boat. This is accomplished by looping the tying line around the bow of the boat while you hold the two ends and walk it aft. If the rope wants to float, put some weight on it such as a spare frying pan to force it down.

As soon as you have the soft patch securely attached to the boat, begin to pump and continue without stopping until the boat is dry. While you are pumping, you should also be heading for the nearest point of safety. If you find the leak is under control and the boat can be kept afloat, you can then alter your course so as to make for port.

**Safe Harbors**

The safe harbor is one which blocks the force of wind and wave so that a boat can lie at its mooring without continuous human attendance. Harbors of this kind are generally landlocked except for a very small passage or opening. Such an opening is very important to us, not only because we must negotiate it entering and leaving the harbor, but because, in a severe storm coming from the direction that the harbor mouth faces, a sea may be created by the entrance which is more dangerous than anything outside. Although there is a time-honored cry of "any port in a storm," sometimes one is a lot better off out at sea. A series of books called *United States Coast Pilots* is published by the Hydrographic Office for all the waters and harbors of the world. While these volumes are directed primarily to the interests of large craft, they give detailed and extremely accurate descriptions which include directions for approaching, entering, anchoring and obeying the conditions of these harbors. The books are inexpensive and are interestingly written and well illustrated.

The major oil companies produce cruising guides and harbor information directed at the small-boat owner. A particularly fine set is published by the Gulf Oil Company and may be obtained simply by writing to the central office in your locale. The ambitious cruising man will also find invaluable the large volume called *Yachting in North America,* published by the Van Nostrand Company. This book contains detailed information compiled by experienced sailor residents from every general area with navigable water. The United States Coast Guard publishes a *Light List of the United States* by which you can recognize visual and audio aids to navigation. *Radio Aids to Navigation,* U. S. Hydrographic Office 209, lists

the radio stations and their codes throughout the world. Volume U. S. Hydrographic Office 205 is the Hydrographic Office publication of radio weather broadcasts. Finally, a telephone call to your nearest Coast Guard Station, United States Weather Bureau, or airport meteorology department will give you surface wind conditions and predictions for the following twenty-four hours. If you are anticipating a trip in open water, these predictions will enable you to plan the best course for the fastest, smoothest passage.

CHAPTER 11

# Basic Foods and Their Preparation

WELL PREPARED, properly balanced meals are as important to the enjoyment of a cruise as they are to the physical well-being of the sailor. A well-designed galley, built around a deep sink, a gimballed stove, and a top-access icebox or food bin, will permit you to produce adequate hot meals in any weather.

If you take your racing seriously you will learn to use dry ice instead of cakes and cubes. This is hard on the highballs but enables you to save several hundred pounds of weight in a distance race. You can keep a small quantity of ordinary ice cubes in insulated bags stowed high in your ice chest for chilling drinks when you arrive in port. Remember that dry ice will solidify the contents of cans and bottles with the resulting danger of exploding them. Remember, too, that foods will have to be defrosted after freezing by this method. Because of this it is wise to use deep frozen foods with dry ice when racing.

Use your imagination in selecting and preparing food on board the boat. There is no need to reduce meals to the level of bare necessity at sea. Try to maintain constant variety and contrast in the flavor and textures of the food and its appearance or color.

## BASIC FOODS

Meat, fish and eggs are primary sources of protein, iron, thiamine, riboflavin, niacin, and phosphorus. Salt-water sea food also provides iodine while both liver and eggs provide vitamin A.

Milk, cream, and cheese are also good protein sources. They are prin-

cipal providers of calcium and riboflavin and contain thiamine, vitamin A, and phosphorus.

Vegetables are important for their minerals and vitamins. Green vegetables are especially valuable when eaten raw. They supply vitamins A and C and calcium, iron, riboflavin, and thiamine. Potatoes, whether baked, boiled, or fried, make excellent low-cost energy foods.

Cereals and grain products, not refined, are good protein suppliers and contain iron, thiamine, and riboflavin. Refined grains, as found in white rice, grits, and Italian *pasta,* cannot be substituted for natural grain.

Butter, margarine, salad oil and lard are good energy foods. You should select the types to which vitamin A has been added.

Fruits, taken fresh and raw, provide vitamin A, vitamin C, iron, thiamine, and riboflavin. Dried fruits, such as figs, raisins, prunes, dates, apricots, are easy to store for long periods of time and are good sources of iron.

Flour is available in an all-purpose variety of blended wheat. It may also be purchased in an enriched form which has vitamins and minerals that make it highly nutritive. The flour is used for bread, cakes, and as a thickener for sauces and gravies.

Baking powders come in three types: tartrate, phosphate, or S. A. S. phosphate but the last type is the most commonly used. The function of baking powder is to give off a gas, carbon dioxide, which leavens the dough.

While spices and seasonings alter the taste of food, fundamentally, the flavor depends on the basic quality of the main ingredients. You should buy spices in small quantities so that you can keep them tightly sealed, or they will lose their volatile oils. Flavoring extracts are packed in kits of small quantities assembled in a wide variety, excellent for boat use. Herbs are also available in kits of small air-tight containers. You will find that basil and oregano go particularly well with Italian food or with any dish containing tomatoes. Chives are especially useful in salads and omelets. Parsley is also used in this manner, as is savory. For meats, sage, sweet marjoram, and thyme are delicate seasonings. Specialized seasonings such as Worcestershire and curry are also easy to carry aboard. There is a general seasoning sold under the trade name Ac'cent, which can be used with any food but is particularly effective with meat. This seasoning is tasteless in itself but accents the flavor of the food on which it is spread. It is known chemically as monosodium glutamate.

## Cooking Meats

Tender cuts of meat can be cooked most quickly and easily. If you sear the meat over a very hot flame and cook it for the shortest possible time you will retain the tenderness and the juice and flavor. The meat will sear most quickly if you do not salt it until you've sealed its exterior by cooking. A cut of meat that is not tender can be soaked with a packaged "tenderizer" containing papaya juice, which makes it very palatable. This



operation takes about five minutes for each side of the meat prior to cooking. It is most effective if the moisture in the meat has not frozen into ice from refrigeration. Frozen meats, except for chopped meat, should be defrosted before cooking. The use of a pressure cooker is advised for the preparation of stews and for the cooking of meats from tough cuts.

The quickest aid to selecting proper cuts of meat is the government grade stamping on the cuts. The highest grade of meat is stamped "Choice." Meats stamped "Good" or "Standard" are entirely satisfactory, flavorful cuts. You will find these stampings on beef, veal and lamb but not on pork. Pick beef that has a velvetlike grain with fine marbly veins of fat. The best beef is rather dark in color. "Good" and "Standard" grades of beef are somewhat redder and have less fat. Cuts of lamb should be more pink than red and this pink is also seen in the bone which should be chosen over cuts where the bone shows white. Pork has a gray cast to the pink color of meat and strong veins of fat throughout. It is imperative that pork always be thoroughly cooked so that it shows no red inside. This is a guard against trichinosis, a muscle-damaging disease carried by pork. Veal has very little fat in the flesh. It is a light pink color but has an edging of fat outside the cut.

Here are some suggestions for cooking meats on top of the stove.

| Meat | Method | Time |
|---|---|---|
| Beefsteak, 1" thick | [1] Pan-broil one side, season and turn over | Rare—5 minutes per side<br>Well-done—7 minutes per side |
| Hamburger steak | Pan-broil—seasonings may be mixed with chopped meat | 5 minutes each side |
| Ham steak | Pan-broil | 5 minutes each side |
| Pork chops | Pan-broil | 6 minutes each side |
| Lamb chops | Pan-broil | 7 minutes each side |
| Veal cutlets | [2] Braise | 45 minutes |
| Liver | [3] Pan-fry | 5 minutes each side |
| Liver | Braise | 20 minutes each side |

## Game and Poultry

There isn't much that can be done besides frying game and poultry aboard a small boat without an oven. Venison is treated as steak and you can follow the directions in the "Table" for beefsteak. Rabbit can be fried or braised in the pan. A young rabbit should fry for forty minutes. A large

[1] Pan-broiling: cooking in pan on stove top with little or no added fat.
[2] Braising: first brown in hot fat; next, cook slowly in covered pan.
[3] Pan-frying: also known as sautéing. Cooking in heated pan on top of stove with enough fat added to prevent sticking and to help browning.

rabbit or hare should be browned first in the pan, then braised for about two hours. Cut the animal into serving portions before cooking, season it and coat it with flour. Venison will need the addition of cooking fat because it is so lean. It can be covered with slices of salt pork or bacon (a process called "larding").

Because of the difficulty of deep-fat frying aboard a boat it is easiest and best to pan-bake chicken. An effective oven can be improvised for this by using a double boiler with just enough water in the bottom to prevent the metal from scorching. In the upper half, melt a little butter or margarine, fit the chicken parts into this, then drain them and cover them with flour. Return them to the upper half of the boiler, cover them with the top, and cook for about one hour. Slices from the breast of chicken can be pan-fried in a little butter until light brown in color. Ham or mushrooms may be cooked in the pan at the same time to flavor and are served with the chicken.

### Fish

Fresh-caught fish should be cleaned as quickly as possible. When you plan to store the fish in the refrigerator the cleaned meat should be securely wrapped in foil or wax paper before chilling. Fish should always be washed before cooking to clean away bits of skin and blood. Light-fleshed fish generally must be cooked in butter as they contain very little fat. Oily-fleshed fish, which have dark meat, can often be cooked in their own fat.

#### *Cleaning Fish*

The first step in cleaning fish is the removal of the head. Using a very sharp knife, cut through the fish behind its skull. The easy way to do this is to follow the line of the gill slits. Work from the belly of the fish toward the back. Use a sawing motion to sever the backbone. Next, slice through the belly of the fish along a center line for its full length. Work the knife in deeply, so that when you spread the halves of the cut apart all the viscera will be exposed. Pull these organs from the fish and, holding the meat apart along the line which you have cut, wash the fish thoroughly, preferably in clean salt water.

If the fish is large enough to fillet, it is easier to slice the meat away from the skin than it would be to scale the fish. Large salt-water fish, like dolphin, are rather smooth skinned and particularly lend themselves to this practice. Filleting simply means cutting the flank of the fish away from the backbone. This can generally be accomplished in such a manner as to leave the ribs of the fish on the skeleton instead of in the meat. You have already slit the belly of the fish to clean out its viscera. All that remains for you to do is make a slice either side of the backbone,



parallel to it, and lift away the fillet. Fresh-water fish, such as trout, can be treated in the same manner or can be cooked whole after being cleaned.

Scaly fish such as the porgy are not so readily filleted. They should have their scales removed so that the flesh can be cooked with the skin still attached. To scale such a fish, first cut away the fins with a strong scissors. These fins are very sharp and can seriously hurt your hand. When the fins have been removed, hold the fish securely by the tail and scrape against the scales with a fish-scraping tool or a heavy-bladed knife. Serrated scrapers are usually fashioned on one edge of the blade of a fisherman's knife. They are easy to use as a knife blade itself and have the added advantage of being less injurious to the flesh of the fish in the hands of an unpracticed cook.

#### *Cooking Fish*

A general method for frying fish in fat is as follows: salt the flesh and coat it with egg and crumbs, or corn meal. Cook for about four minutes in boiling fat and drain on paper towels before serving. Swordfish and halibut can be fried in butter directly without coating. Cook until brown on both sides, adding more fat if necessary. Cooking the fish with strip bacon is a good way to provide the frying fat and vary the taste of the fish.

Steaming may be difficult on a small boat, but it is possible to boil fish in a kettle. First, sprinkle the fish with salt, then wrap it in cheese-cloth or paper. Season the water with onion, carrot, or bay leaf. The boiling water should be deep enough to cover the entire fish. If you're going to boil the fish as a whole, you must allow between eight and ten minutes cooking time per pound. Cut as steaks, the fish should be boiled for about twenty minutes. Serve with a sauce made from melted butter and lime or lemon juice.

### Shellfish

Shellfish include clams, oysters, lobsters, shrimp, scallops, and crabs. As with other fish, there are certain seasons during which the flesh tastes at its best. There are also certain waters in which contamination makes all sea life unsafe to eat. It is important that you consult experienced people in your locale to determine where, when, and what sea food is safe. In the United States, the State Fish and Wildlife authorities can be consulted.

#### *Clams*

Clams are generally served steamed, or as fritters. For steamed clams you should allow about one quart per person. Soft-shelled clams are the best for this. First you must scrub them thoroughly in several changes

of water to remove sand. The clams should steam in a large kettle which contains about two tablespoonfuls of water for each quart of clams. Cover the kettle and cook slowly for about twenty minutes. Now transfer the opened clams into individual dishes with a side dish of melted butter. A little lemon or lime juice makes an excellent seasoning. The water remaining in the kettle is a tasty broth which you can serve right with the clams.

To make clam fritters, open the shells, remove the clams and cut off their necks. Now chop the body and drain off the juice and water. Add some milk to the juice to get about half a cup for each pint of clams. Mix one egg with the juice and shake in two-thirds of a cup of flour, three-fourths teaspoon of baking powder, half a teaspoon of salt and mix thoroughly. Prepare hot bacon fat in a frying pan and drop in the mixture containing the clams a spoonful at a time. Cook until brown and drain on paper towels.

*Boiled Lobster*

You'll want a large kettle for this. Fill it about three-quarters of its depth with water; if the sea water is clean you may use it, otherwise use fresh water and add two tablespoons of salt for each quart. When the water is boiling rapidly, put in the live lobster and cover the kettle. It will take a few moments for the water to resume boiling. From the time it starts to bubble again count off about fifteen minutes, remove the lobster and serve hot or chilled. A mayonnaise dressing or thin slices of lime or lemon make good seasoning.

*Oysters*

Along the Atlantic seaboard and the Gulf of Mexico, oysters are out of season from May through August. On the Pacific coast they are in season all year round. For boat use the simplest preparation is to fry or pan-fry the oysters. You want at least half a dozen per person for an average serving. After removing the oysters from the shell, drain them and catch the liquid in a separate container. This can be heated and served as a thin broth or chilled and used as a "cocktail." Dry the oyster meat between rolls of paper toweling. An egg mixture of two eggs beaten together with two tablespoons of milk, a teaspoon of salt and a touch of pepper will prepare oysters enough for four servings. Dip each oyster in the mixture and roll in corn meal. Pan-fry in hot fat until brown and drain on paper toweling. Scallops are prepared in the same way as oysters.

*Shrimp*

Shrimp are easily boiled or fried, and you can boil them either in or out of the shell. In either case, wash the shrimp first. Bring a pot of water to a boil and add one tablespoon of salt per pint for shrimp still in the shell. One-half tablespoon per pint will be enough for peeled shrimp. Sea water is satisfactory if it is clean. Drop the shrimp into the boiling water and cover them. From the time the water begins to boil count five minutes. Remove the shrimp and put them in ice water to cool them.



Fried shrimp should be peeled first. Remove the sand vein of the shrimp after cutting it almost through fore and aft. Now prepare a coating of egg and salt, and dip the shrimp in it, then roll in the corn meal. Fry the shrimp in fat to a golden brown and drain on paper toweling.

*Crabs*

Soft-shelled crabs are readily pan-fried. Hard-shelled crabs may be boiled like lobster. To fry the soft-shelled crab, remove the meat from the body and wash it thoroughly. Then salt the meat on both sides and drop in hot fat until golden brown. Drain on paper toweling.

For hard-shelled crabs, fifteen minutes in boiling water containing salt is adequate.

**Vegetables**

The dark green and dark yellow vegetables are the most important for providing minerals and vitamins. Most vegetables can be stored without refrigeration and will last well if ventilated and kept from the sun. Vegetables that you plan to eat raw are best washed, bagged, and stored in the ice box. If you must cook vegetables, do so quickly and at high temperature. This will make them most tender for the least destruction of their natural taste. The usual procedure for cooking vegetables is to drop them in boiling water and cover them. When the water begins to boil again remove the cover and finish cooking in an open kettle. Cooking destroys many vitamins and mineral salts. To help counteract this loss, cook the vegetables in their own skins whenever possible. You should also cook the vegetables whole rather than in small pieces which exposes too much surface to the water. Finally, serve the vegetables immediately after cooking. Certain vegetables, such as spinach, contain so much water naturally that it is unnecessary to add water from the outside. You can cook these vegetables in heavy metal utensils with tight-fitting covers. It is also possible to use a heavy shallow pan and cook the vegetables by steaming them in very little water.

When you are planning trips of long duration, you can pick vegetables such as tomatoes and squash when just a little green and not yet ripe. These will keep particularly well without refrigeration, longer than ripe vegetables. Cucumbers, too, and corn can be carried a long time. Onions, potatoes, and some salad greens will last indefinitely in a dry ventilated area.

It is particularly important that you wash all vegetables thoroughly before using. Vegetables may contain or carry a variety of contaminants until they have been washed. These contaminants which are dangerous to the consumer include intestinal parasites, often transferred to the vegetables through fertilizers or farm animals, and the variety of poisons used by the farmer to protect his produce from farm parasite attack.

**Basic Stew**

Basic stew to serve four people on board the boat will require about one and one-half pounds of meat trimmed free of fat and browned in a frying pan. After browning, put the cubed meat in a kettle containing two cups of boiling water to which salt and pepper have been added to taste. Simmer for about two hours. Now add diced vegetables including two or three carrots, half a dozen small onions whole, three medium-sized potatoes. Now cook for an additional thirty minutes with the vegetables, adding water as necessary to maintain the level. At the end of this time, add one or two tablespoons of flour to one-quarter of a cup of cold water, mix and add to thicken the stew, then serve.

**Basic Chowder**

The principle of chowder is the same as that of stew. Boston chowders contain milk whereas Manhattan chowders contain tomatoes or tomato juice. The stock from which the chowder is made is generally salt pork. Render the fat from the salt pork by cooking in a sauce pan or double boiler. Remove the crisp pork which can then be used later for a garnish. Onions and celery are put into the fat and cooked until yellow. Then potatoes, salt and pepper are added. Thyme is a good seasoning to add at this point. Use just enough for your own taste. Fish, clams, lobster, or shrimp are now prepared to put into the chowder. Cut the sea food to the size you desire and heat it until it boils in its own juice. Now add the milk or tomato juice to the sea food and add them together to the chowder. Add additional seasoning to your taste while the mixture simmers, but does not boil.

**Bread**

Food value of bread depends upon the proportion and qualities of flour, yeast and milk used. For boat use, rye bread and pumpernickel keep best and are the most nourishing. These breads if purchased unsliced will keep extremely well in a dry airy spot. They will keep particularly well in the icebox but lose their fresh taste quickly. Bread should be wrapped tightly in aluminum foil before putting it on the ice. A touch of mold on the outside of a loaf is not sufficient damage to warrant that you throw the loaf away. The mold can be scraped off or cut away where its damage to the bread is not extensive. However, bread which is shot through with mold everywhere should certainly be discarded at once. Any bread makes good toast and this is easily accomplished over the open flame of the cook stove. Simply hold the slice of bread above the flame on a long-handled fork, turning it till both sides are crisp.



"Brown-n-serve" breads and rolls are particularly good supplies for the boat. These pre-baked products will keep perfectly on the shelf or on ice until you are ready to consume them. You can brown them in the upper half of a double boiler which is used dry, as an oven. It is also possible to brown them by enclosing them in a loose wrapping of aluminum foil placed near but not directly over the flame of your stove. This acts as an oven would, delivering uniform heat. Bread and rolls which have become dry can be freshened up by sprinkling lightly with water, then reheating in aluminum foil.

*French Toast*

Making French toast is a particularly good treatment for bread which has started to go stale. To make six slices of toast you will need two eggs, one cup of milk, and about one-quarter of a teaspoon of salt. Beat the egg first, then stir in the milk and salt. Let the bread stand in the mixture until it has saturated itself. Cook in a frying pan in melted butter until golden brown. Serve with jam, tinned fruit, or cinnamon sugar.

**Basic Muffins**

Two cups of sifted flour, two and one-half teaspoons of baking powder, one egg, one cup of milk, one-half teaspoon of salt, and three tablespoons of sugar, together with one-quarter cup of melted fat, are the ingredients for muffins. The salt, baking powder and sugar are combined and the flour is sifted into the mixture. Next, add the unbeaten egg, the milk, and the fat. This should be stirred until thoroughly mixed, but the mixture should not be beaten. The dough can be cooked in lumps about the size of a silver dollar, half an inch high. You can make up little cups from aluminum foil molded with your fingers for each muffin. Grease these cups with butter. Then, place them in the upper half of a double boiler which you are going to use as an oven. The double boiler should be hot before you start. Half an hour is about the correct cooking time. You can sound one muffin with a fork or the point of an ice pick to test the consistency at the center. When it is properly cooked dough will not adhere to the inserted instrument.

**All-purpose Flour**

An all-purpose flour, made from a blend of different wheats, is satisfactory for all the general uses aboard a boat. Not as delicate as a cake

flour, it is nevertheless applicable to pastry, bread, or gravy thickening. The all-purpose flour should be moved from the box in which it was purchased and stored aboard the boat in two or more sealed jars. Fill the jars to the top of their necks before closing. This eliminates damp air which will make the flour stale or mold it. Basic biscuits can be made from this flour. These basic biscuits, used plain, are excellent emergency rations. With the addition of nuts, fruits, or crisp bacon, they can make a pleasant addition to the sea-going diet.

## Eggs

Eggs are particularly useful aboard a boat because of their high nutritional and protein values, the fact that they can be kept without refrigeration for reasonable periods of time and their facility for combination with other foods. If you are storing eggs for unusually extended periods of time, they will keep best in a brine solution or tightly covered container. It is best to let eggs which have been in the icebox come to room temperature before attempting to boil them. This is a precaution which guards you against cracking the shells in the hot water. Never cook eggs at high heat.

### *Poached and Soft-boiled Eggs*

Poached eggs can be made in a frying pan containing about an inch of water and half a teaspoon of salt. The water should be brought to boiling and the eggs, removed from their shells, slid carefully into the water. Cover the pan and cut off the heat, letting the eggs cook for about four minutes. Egg poaching cups are available which are mounted above the boiling water and hold one egg in each unit. These units should each be greased with a bit of butter or margarine before dropping in the egg. The finished poached eggs can be served on toast directly, added to hash, or covered with a ready-mixed cheese sauce.

The only way to control the viscosity of a soft-boiled egg is by timing. Put the eggs in a pan and cover them with cold water. Sea water is satisfactory. Bring the water to a boil as rapidly as possible. At the moment the water is boiling vigorously, cut off the flame and cover the pot. Let the eggs stand for two minutes if you like them very soft, four minutes if you like them firmer.

### *Hard-boiled Eggs*

To hard boil eggs, it is best to introduce them into water already boiling. Cover the pot to help retain the heat. The flame should be lowered so that the water remains just below the point of violent boiling. About one-half hour is the required cooking time. When the eggs are done, put them immediately into cool water to help avoid the discoloration that sometimes



occurs on the exterior of the yolk. Store hard-boiled eggs in their own shells until ready for use.

### *Omelet*

An omelet for four people requires five eggs. You will also need about five tablespoons of milk, three-quarters of a teaspoonful of salt and about a tablespoon of butter or margarine which you must melt into your frying pan. Break the eggs into a bowl and mix the yolks and whites together. Now, beating, add the milk and any seasonings you desire. Seasonings can include parsley, chives, cheese, or bacon. Pour the omelet into the pan, which should be on a low flame. Whip the omelet all around continuously while you cook so that the still-liquid portions will flow down to the heat. When the omelet no longer flows, turn up the flame for a minute to brown it. The total time elapsed will be about ten minutes. The omelet is generally folded in half to remove it from the pan without breaking.

A delicious Cuban dish is omelet with fruit and rum. Before the omelet is folded, cover one-half of it with mixed fruit cocktail. Now make the fold and, on top of the omelet, spread a thin layer of sugar. Onto the sugar pour a teaspoonful of cocktail rum or cognac. The alcohol is lighted with a match and allowed to burn itself out. The finished product is altogether sensational.

### *Scrambled and Fried Eggs*

Scrambled eggs are generally the illegitimate result of attempting to cook fried eggs in a rolling boat. If you deliberately plan to scramble eggs, its best to do the stirring in a bowl, adding about two tablespoons of milk for half a dozen eggs and three-quarters of a teaspoonful of salt. The mixture is poured into a pan of medium temperature containing a bit of melted butter. You must continue to stir the eggs while they cook. Cook the eggs just until they jell and serve at once.

It is difficult enough to cook eggs sunny-side-up on board a boat, but the acid test of the sea-going chef is the production of eggs-over-lightly, served with the yolk intact. The eggs should be fried with a little bit of butter; if you're planning bacon and eggs, fry the bacon in the pan first, then pour off the excess fat and use the remainder for cooking the eggs. Eggs cooked in bacon fat generally need no further seasoning.

## Cheese and Cheese Dishes

With the exception of cottage cheese and cream cheese, which need refrigeration, most cheeses will keep very well stored in a cool place with good ventilation. During the storage time, the cheese may grow mold on its exterior. This mold can be wiped or scraped off and does no harm to the cheese. However, if mold has penetrated the entire mass, the cheese

should be discarded. Grated cheeses are available in package form as seasoning which can be used for Italian foods and for soups. American Cheddar cheese is an excellent general cheese for cooking. The strong cheeses, blue cheese, Gorgonzola, Stilton, and Roquefort, make delicious cracker spreads. Milder spreads include Swiss cheese, Gruyère, Cheddar and Edam. The varieties of cheeses are infinite but these just named are easy to store aboard. Odorous cheeses can be wrapped in damp cheesecloth to keep them from drying. Then they should be wrapped in aluminum foil, freezer wrap, or plastic bags for storing so that their odor will not spread through the icebox to the other foods.

*Cheese Balls*

As an appetizer or side dish, Parmesan or Cheddar cheese can be made into balls fried in fat. One cup of grated cheese mixed with two tablespoons of flour, a touch of cayenne and half a teaspoon of salt form the base. Remove the white from an egg and beat it until it is stiff. This is added to the cheese mixture and thoroughly worked in. Form balls about the diameter of a five-cent piece and roll them in meal or crumbs. Fry in fat until they appear golden brown and serve alone or as a side dish.

*Welsh Rarebit*

A Welsh rarebit is made of American Cheddar cheese. To serve four people you will need half a pound. A tablespoon of butter, one tablespoon of flour, one cup of milk, and a bit of salt, pepper and mustard are stirred together in the top of a double boiler. This stirring together should follow a rigid step-by-step procedure. First the butter is melted. Second, the flour is added. Third, the milk. Finally, the seasonings. Stir very slowly until the sauce boils. You may need direct heat to bring this about. Once the boiling takes place, however, return the upper half of the double boiler to its place over the hot water and add tiny bits of the cheese while stirring. When the cheese is all melted and the mixture is very smooth and uniform pour it over toast and serve. Welsh rarebit can be augmented with bacon, mushrooms, fresh or cooked tomatoes, or bits of spicy meat.

**Packaged Foods**

The majority of packaged foods available today require no special skill for handling, no refrigeration, and the addition of little or no water. These factors alone would make them highly desirable for boat use but there is a bonus factor besides, which is that the variety of prepared foods available is almost infinite. It is possible not only to stock a tremendous range of provisions, but the size of the portions available in tins, packages, and freezer units obviates the problem of handling leftovers and minimizes weight. For small-boat use, particular attention should be given to selecting those packaged foods which require the least added water. Many soups



are available which are not in concentrated form. Those which must be diluted or are packaged as cubes to be added to a total volume of water are entirely satisfactory for any use except long voyages. The cubed bouillons, for example, are especially practical because the concentrate can be added to each individual cup of water directly. This is most appreciated in very rough weather because the water can now be boiled in a stable, splash-proof kettle instead of in a soup pot.

Tinned meats, such as ham, chicken, pork loin, and beef, are all packaged in sealed containers so that they require no refrigeration until they have been opened. However, it is important to read the label on the container as many brands produced in the United States cannot be treated this way. For some reason, the Danish, Dutch, and Latin American meat packagers seem to be able to produce low cost, high quality items which need less attention than those manufactured in the United States. Almost all of these meats can be eaten without additional cooking. However, they are more palatable and beneficial to the crew's morale if you pan warm them before serving.

Many dried-food products are available today which, upon the addition of water, can be cooked or served so that they are indistinguishable from fresh foods. Among these are mashed potatoes, which make a filling, tasty, solid food to round out the menu in rough weather. Dried soups such as onion soup and *minestrone* or vegetable may be obtained which are quickly prepared in boiling water. Most of these dehydrated foods can be improved with the addition of a bit of milk. Italian *pastas,* such as spaghetti and noodles, should be drained in several changes of water if you are cooking them from the original dough. This draining removes the starch. The *pasta* can be cooked by boiling in sea water or in salted fresh water. Approximately ten minutes boiling is required for proper cooking. Packaged rice can be cooked without preliminary washing, but rice purchased in bulk must be washed and cleaned. Rice should be added to boiling water by shaking in a little at a time or it will ball up and not cook properly. When all the rice has been added to the boiling water, cover the pot and continue to cook for about twenty-five minutes. Sea water or fresh water with added salt can be used.

**Fruits**

Apart from their vitamin and food values, fruits make tasty deserts and snacks for the crew. If you are planning a long cruise, buy fruits which are not yet ripe and allow them to mature in a cool, well-ventilated place. Ripened fruits can be stored in the icebox. Fruits which will be eaten without cooking should be thoroughly cleaned to remove traces of spraying. Apples and hard pears help clean the teeth by mechanical scouring action. Fruits such as apples, pears, bananas, and oranges are most con-

venient because they are consumed as individual servings. Melons and berries are difficult to eat under way but they are delicacies when served with meals after the anchor is down.

Pineapple, fresh or from tins, is not only eaten uncooked but may be fried with ham to give a sweet, rich flavor to the meat. Paper-thin slices of lemon or lime can be cooked with veal, fish, or egg dishes. The citrus juice will season the dish while it is cooking, and the crisped slices of fruit can be used to garnish the dish when serving.

## Beverages

Tinned beverages which need no added water can not only be kept in the icebox to provide refreshing drinks but make a good source of emergency liquid ration which can be stowed in the dinghy, the life raft, or rescue kit. Proper choice of such beverages should include the slightly sweetened fruit juices which are vitamin C enriched. You must be certain to purchase the kind which need no refrigeration to keep them from spoiling.

### *Coffee*

For a small-boat sailor, the most practical source of coffee is in instant powdered form. For the diehard who prefers his coffee fresh, a drip pot is the simplest device to use aboard the boat. In any case, powdered or fresh, coffee should be kept in small containers filled to the top to preclude deterioration from air.

Chefs in the restaurants of top-quality hotels will all assure you that the secret of good coffee is a combination of fresh materials and scrupulously clean equipment. Coffee beans contain many volatile oils which are released in cooking. These contaminate the pot and destroy the flavor of subsequent brews. Rinsing the pot with soap, or detergent, and water is not adequate. The pot and all its parts must be scoured to remove the accumulated by-products of boiled coffee.

### *Tea*

While English readers may raise their brows in scorn of the lowly tea bag, for boat use it is much the most practical brewing device. Select tea which is packaged in cellophane or plastic bags. The bags made of cloth do not protect the tea as well from going stale. Tea should be made with freshly boiling water in perfectly clean pots or cups.

For iced tea, oolong or congou are best because they remain clear even when iced. Freshly made hot tea can be sweetened in the original pot. This makes it most easy to dissolve the sugar which will resist going into solution in the ice water. To help save ice, brew a strong but small amount of tea and partly dilute it with water from your tank. This will reduce



the temperature considerably so that when you pour the liquid over the ice it will not melt it all at once.

### *Chocolate*

Chocolate, or cocoa, which are varieties of the same thing, is available in many forms. For boat use, "Dutch Process" cocoa is the most easily soluble and can be used for many cooking purposes. Instant cocoas are available with sugar and emulsifiers mixed into the product and need only be added to hot milk to make a drink. Prepared chocolate syrup can be purchased in small tins and added to whole milk, powdered milk with water, or condensed milk with water to make a drink. The chocolate syrup is much more effective for cold drinks than are the powdered cocoas and chocolates.

### *Water*

The fresh water in the tanks of your boat is the most vital thing you have on board for your own well-being. It is important that the water which you take aboard is uncontaminated, or purified. In most cities on waters of the United States, safe drinking water is available. However, you must ascertain that the source from which you draw your water is connected with an approved supply. Many rural areas have their own wells and occasionally water which is to be used for irrigation is in a drainage area, which makes it unsafe for human consumption.

The water tanks on board your boat will accumulate a vast amount of water-carried by-products through the years. The tanks must be provided with hand holes through which you can scrub the interior of the tank, everywhere, including the top and baffles. The tank should be scrubbed with water containing a bit of detergent and disinfectant such as Clorox, then thoroughly rinsed. After rinsing, the tank should be dried and allowed to air so that all fumes from the disinfectant will be carried off. During this airing process, guard the opening of the tank against the entrance of further contamination. This can be accomplished by supporting a plywood scrap above the opening with several bits of wood.

Water-purifying chemicals can be obtained from war surplus, camping-goods suppliers or through your pharmacist. The addition of iodine to the water in the tank, about five drops of iodine per gallon, makes for good protection against parasites in the water. It will also keep down the incidence of algae or scum. If you have serious doubts about the purity of the water, the safest procedure is to boil it for several minutes before using it.

Don't trust water just because it looks clear and tastes all right. Be certain you know the source before you put it in your tanks. If you must use unknown water, do so only after boiling or chemical treatment.

## Galley Utensils

In selecting tableware for use aboard your boat, you have to compromise among several requirements. Tableware must be high sided. Shallow, curved bowls, or v-shaped cups, bowls and glasses splash badly in the slightest disturbance. You must select tableware with nearly vertical sides, sufficiently deep so that they hold adequate portions even when only half filled. The tableware must be of material which is easily cleaned and doesn't hold food stains. The tableware should also have a rough, or nonskid, base which you may have to provide yourself, sanding the bottom or pasting on a high-friction surface, like that of sheet rubber. There are many good quality plastics available today, such as the melamines. Some of these have substantial weight and feel. China, too, is entirely satisfactory. It generally has a rough base which keeps it from sliding on the decks or table, is altogether sanitary, and quite pleasant to use. If proper, deep, close-fitting lockers are made for tableware, there is little danger of china breakage.

Knives, forks, spoons, spatulas and cooking pots and pans for boats are best made from stainless steel. Stainless-steel knives are the hardest to keep sharp, and the material does not spread heat as evenly as copper, iron, or aluminum do. But its cleanliness and corrosion resistance outweigh these other considerations altogether. Under no circumstances should metal be used for cups and glasses. It conducts heat to a dangerous degree and can deliver quite a serious burn to the user.

Common, household steel wool rusts too badly for shipboard use. As a substitute, purchase bronze wool, Monel wool, or stainless-steel wool, all available in food and hardware stores. You will find, too, that liquid detergent is invaluable about the galley. With detergent you can do the heavy part of washing in salt water and save the precious fresh water in your tank for sponge rinsing and for drinking. You will want a good abrasive cleaning powder for stove, frying pan, and sink use. A pair of plastic dispensers for paper hot-drink and cold-drink cups will reduce your galley time and overhead. Carrying generous amounts of aluminum foil is another work-saving technique. Use the foil to line your pans before cooking supper and you can clean the pan in a moment when you're through. Foil is also important as an icebox wrapper. You should carry generous quantities of paper towels on board. They will be used for everything from galley work through engine room consumption, where you will use them for hands, tools, and bilge cleaning.

Finally, make it a point to free the cook from after-meal cleaning. If the cook has prepared the meal, it is no more than fair that the rest of the crew restore the galley to fighting trim. Never forget that a good cook is the most valuable asset of the crew. Once it is known that a cook is good



he never has to wait long for invitations to sail. If you want him to sail with you, you have to provide fringe benefits. When you have established the cook for your trip, let his word in the galley be law. He, alone, knows his plans and schedules for the food. Wild, midnight forays to raid the icebox may reduce the final days of the cruise to a candy bar survival level.

### Essential Galley Supplies

1. Double boiler
2. Frying pan with cover
3. Pot or kettle with cover
4. Spatula, or egg turner
5. Large carving knife
6. Individual steak knives
7. Cooking forks and spoons
8. Large can opener (hand-held type is preferable to mounted type)
9. Ladle
10. Strainer
11. Mixing bowl
12. Vegetable peeler
13. Cutting board
14. Ice pick
15. Rolls of aluminum foil and waxed paper
16. Rolls of paper toweling
17. Measuring cup and measuring spoons
18. Kitchen tongs
19. Kitchen shears
20. Paring knife

### Useful Galley Extras

1. Aluminum griddle to cover one or more stove burners
2. Egg-poaching cups
3. Portable or folding oven
4. Thermometer (unbreakable)
5. Flour sifter
6. Egg beater
7. Aluminum-foil cooking pans
8. Portable over-flame toaster
9. Serrated knife

# CHAPTER 12

## Safety at Sea

### HEALTH

#### The First-aid Kit

SAFETY AT SEA begins with knowledge used in a logical way and augmented by proper preparation and good equipment. We shall open our discussion by itemizing the contents of a proper marine first-aid kit that should be kept aboard the boat at all times. A particularly good kit contained in a watertight metal box is manufactured by Johnson & Johnson. For certain drugs which you should carry when cruising inaccessible spots, you will need a prescription from your doctor and his special recommendations concerning their handling and use. These drugs are the painkillers, narcotics and barbiturates, and the antibiotics. They are dangerous if used indiscriminately. Moreover, people react to them in individual ways and violent disturbance or death may result from allergic reactions or from mishandling. Nevertheless, you or your crew may someday have to face an acute appendix, a broken leg, or other serious pain conditions when you are far from the security of medical assistance. Because safer drugs become available at increasingly frequent intervals, whenever you plan to venture great distances from medical contact, you should confer with your physician to obtain his up-to-the-minute recommendations.

CONTENTS OF A FIRST AID KIT

1. One-inch roll bandages, ten yards
2. Three-inch roll bandages, ten yards
3. Sterile gauze, five yards
4. Absorbent cotton, large roll





5. Waterproof adhesive tape, one inch width, ten yards
6. Large sterile gauze pads, one dozen
7. Sterile eye pads, one dozen
8. Triangular bandage
9. Tourniquet
10. Applicators for cotton, one small box
11. Bottle of antiseptic
12. Six ampules of ammonia
13. Blunt-nosed scissors
14. Curved tipped forceps, best quality
15. Wound clips and their applicator
16. One jeweler's loupe (a powerful single eyeglass) for magnification
17. One tube of burn jelly
18. One bottle analgesic
19. One bottle boric acid solution for eyes
20. One bottle milk of magnesia tablets
21. One bottle motion sickness pills
22. One bottle antihistamine tablets
23. One bottle universal poison antidote: 2 parts activated powdered charcoal; 1 part magnesium oxide; 1 part tannic acid. Add two spoonfuls of this to one glass of water. Recommended by Dr. John Henderson, M. D., F. A. C. S., Medical Director of Johnson & Johnson.
24. One bottle of hydrogen peroxide solution
25. One-ounce bottle oil of eugenol
26. One ounce zinc oxide
27. One First Aid book. Recommended is *The Complete Book of First Aid*, by Dr. John Henderson, M. D., F. A. C. S., published by Bantam.

The first-aid kit should be stowed in a readily accessible place. If the boat has a toilet room, this is the most common location for its stowage. Mount the kit on a shelf of its own if possible. The kit should be high enough above waterline so that if the boat is capsized or damaged the first aid kit can still be reached with the smallest amount of difficulty. Don't hide the kit behind closet doors. Fasten it where it can be seen and make sure that it can be easily identified. One method of making the kit conspicuous is to decorate its exterior with a large white cross on a dark red field.

#### *The Teeth*

Although there are a number of good first-aid books which deal with major damage to the body, there has been no good compendium of care and maintenance of the teeth. Donald George Smith, D. D. S., is an experienced international yachtsman as well as a dentist and has written this following section on general and emergency care of the teeth at sea:

The best dental treatment is proper preventative maintenance. You

yourself know when you have last seen your dentist. Have your teeth checked before you start on a cruise.

Temporary fillings and bridgework, unless of a hard, durable, semi-permanent type, are not to be trusted for any great length of time. The materials in some of these devices may chip, exposing sensitive surfaces of the teeth. Decay may occur due to improper fit of a temporary restoration coupled with inadequate mouth hygiene. Cramped quarters and irregular eating schedules are bad influences on physical hygiene. It is even worse when heavy bad weather adds an occasional emergency diet of warm beer and candy bars. Your body seems able to stand this lowered intake of vitamins and minerals for some time, running on its reserve. This does not in itself affect the teeth.

Except for dietary deficiency of long standing and some generalized systemic diseases most disorders of the teeth and mouth are the direct result of food debris remaining in contact with them. Broadly, these disorders are cavities and gum disease, or periodontoclasia. Both of these diseases are caused by bacteria and both can be controlled by removing the food debris in which the bacteria live. You must remove it immediately, before they can grow, multiply, and cause trouble. You can't live without food, and neither can the germs which cause mouth disease.

The first step to mouth hygiene is always to carry a toothbrush. In addition, you should thoroughly rinse your mouth with fresh or salt water after cleaning. One advantage of the thorough-rinse plan on a boat is that when the weather gets nasty you may not even have to reach for water. Salt water is quite beneficial in the treatment of gum disease as it tends to draw out accumulating fluids and toughen the overlying gums.

Emergency treatment of dental disorders consists primarily in relief from pain and prevention of the spread of infection. These disorders can prove a severe threat to health and comfort in a very short period of time. Here are some recommended treatments:

1. Generalized sore mouth with or without bleeding, red sore gums, with or without grayish-yellow or white edges next to teeth, bad breath: treatment: isolation of drinking and eating utensils, mouth wash with three per cent hydrogen peroxide (store type is three per cent) held in mouth for five minutes, salt water rinses for five minutes every hour, pain prescription such as aspirin to soothe, and antiseptic mouth wash.

2. Toothache sensitive to heat or cold: try to locate the cavity and pack with a paste of oil of cloves and zinc oxide. Pain prescription such as aspirin.

3. Toothache sensitive to percussion or pressure or movement, throbbing or long steady ache: pain prescription: zinc oxide, eugenol, ice pack, rest with head higher than feet.

4. New fillings (may hurt in cold wind or rain due to the fact that the dental nerve has not yet adapted to the surgery on the tooth and to the foreign filling material): pain prescription: cover with wax or thick zinc oxide and eugenol to insulate.



5. Swelling of gums, gumboil, no generalized sickness: rinse with warm salt water; if it forms like a boil, lance with sterile sharp-pointed instrument to draw pus. If it is a larger area, over one inch in diameter, summon professional help.

6. Smooth, painful swelling of face and neck: must be considered very serious. Medical and dental help should be summoned immediately. In some of these cases, breathing may become impaired or brain infection may result.

7. Lumpy swelling in neck coupled with dental pain: should be seen by dentist as quickly as possible.

8. Broken fillings: make paste of zinc oxide and eugenol, and pack in exposed area.

9. Broken teeth: mixture of zinc oxide and eugenol covering exposed raw nerve; do it as soon as possible after accident for it is less painful then; may be held in place by some sort of cap improvised from wax or adhesive.

10. Loosened teeth: move back into position with clean fingers, retain in position with wire, e.g., copper electrical wires. Make one long loop around several teeth, preferably including some strong teeth. Then make short loops to go between the teeth and around the first long loop so that you can tighten it up between each tooth. Tuck the ends of the wire back in between the teeth.

11. Teeth knocked completely out of socket: successful replacement doubtful even when treated in dental office; if antibiotics are available, teeth are clean and a method of holding them thoroughly in position is available, there is a chance of success. However, much pain is to be expected and the possibility of infection is great. Must be seen as soon as possible by a dentist. It is strongly recommended that you simply forget about such teeth.

### Accident Prevention

Accident prevention is fundamentally the province of each member of the crew. The skipper of the boat, however, can greatly reduce accident risks in two ways. First, he can provide aboard his boat proper mechanical safety measures, such as railings, antiskid surfaces on decks and cabin tops, life-saving equipment and proper maintenance of this equipment. Second, the skipper can use his discretion in the assignment of specific tasks aboard the boat to crew members whose physical condition or experience makes such work the least hazardous.

There are times in racing and cruising when enthusiasm overwhelms

intelligence. Extreme caution is a detriment to the making of a champion, but the consistently successful sailor or athlete must nevertheless function within the safe limits of his ability. A good skipper will keep his crew well rested, well fed, warm and dry. He will keep himself in the same state as the crew because the safety of the vessel as a whole depends upon his decisions. To make a passage in a boat where crew comfort has been neglected, so that the men become rundown, irritable and careless, is to invite disaster. Attention to such details as maintaining tight decks so the crew need not sleep in damp bedding and equipping the galley with a gimballed stove on which hot meals can be prepared in any weather are among the most fundamental steps toward successful cruising.

It is also the responsibility of the skipper to see that each crew member has proper nonskid shoes, adequate foul-weather gear, several changes of dry clothing, and a place to stow his personal belongings where they will be accessible to him at all times. On a small boat, friction among crew members can arise from such a simple thing as one man having to disturb another who is sleeping so that the first man can get his oilskins before a squall.

Adequate bunk boards and cabin handrails are genuine necessities for safe cruising. Of equal importance is pumping the bilge, the level of which should always be kept at a minimum. Bilge water, beside having great weight which can affect the stability of the boat, may splash above the cabin sole boards making their surface slippery and soaking and chilling gear and clothing which has fallen to the floor. Deep, well-anchored ash trays reduce the danger and discomfort of smoking below deck. If there are nonsmokers in the crew, who object to the odor of tobacco, it is better if the skipper limits smoking to the deck and cockpit areas. Seasickness can occur to even the most experienced sailor if conditions are set up for it.

**Seasickness**

Motion sickness is laughed at only by those who have not experienced it. Some sailors are able to carry out their work without great loss of efficiency even when quite ill. Most of these men will argue that concentration on their work is beneficial to them and reduces the time of discomfort. It is wise to let these men work about the cockpit where they are not in danger of going overboard. Motion sickness is predominantly the result of shifting of the fluid in the semicircular canals of the ear. These semicircular canals also function to give the individual his sense of equilibrium, or balance. When the perception of equilibrium is disturbed by violent motion, loss of balance control may accompany the feeling of nausea. Seasickness is usually also accompanied by physical weakness and the spasms of vomiting. You can see that persons so afflicted would be in real danger on the deck of a small boat. It is important, too, that you make sure the seasick crew member does not suffocate or drown. On one especially tragic ocean-race



return trip, a seasick crew member, lying on his side in the lee quarter of the cockpit, drowned. He lay with his face immersed in water which had gurgled up through the cockpit drain and he was too weak to signal for help or to move himself to a safe position.

The serious consequence of the regurgitation in seasickness is dehydration, or loss of body water. The seasick member must be made to swallow small amounts of water from time to time even though he may throw them up again shortly afterwards. Generally, a warm broth of nourishing stock, such as beef broth, taken with some solid food can be tolerated. You should discuss with your physician his recommendations of drugs which will tranquilize the spasms of a seasick crew member. These spasms, carried to extremes, can result in severe internal damage.

The best guards against seasickness include proper physical tonus, warm dry clothing, bland solid meals, and abstention from irritants. It is easier to prevent seasickness than to cure it. Preventative drugs are most successful if taken one or more hours before starting the trip. The skipper will be well advised to make it a shipboard rule that the crew members and he take a motion-sickness preventative before starting a trip. The wise skipper will also refuse to sail with a crew who are fatigued or hung over from partying before the trip.

**Intoxicants**

Alcohol, ordinarily referred to as a stimulant, is actually an inhibiter. Although it sounds like a play on words, alcohol inhibits your inhibitions, thereby affecting your judgment. While the effect of a given amount of alcohol on a human being is largely an individual thing and correlated with the body weight, the idea that particular persons are immune to its effects is only myth.

While a proper nip of dew can take the chill from the night sea air, common sense demands that you do your drinking when the anchor is down and the sails are furled. No successful athlete would consider drinking when training for his sport. Getting about on the moving deck of a small boat sometimes requires all the equilibrium you can muster. Moreover, making decisions concerning such delicate things as current, rocks, and wind may take some fine-line thinking. It is hardly within your province to risk the well-being of your crew and boat by doing your drinking under way.

**Sharks and Shadows**

There's an old saying about danger lurking in shadows and in a nautical sense that is often true. Sharks and barracuda often swim or lurk in the shadow of a boat to conceal themselves from the fish that they are hunting. For this reason, you should under no circumstances swim from your boat

in waters where these fish are known to live. It is far safer to go ashore and enter the water from a sandy beach where you have good visibility.

It is worth noting that shark and barracuda attacks are not limited to deep water. Full grown sharks are known to come in water barely deep enough to float them and will often attack with no warning. There is no truth to the belief that sharks must turn on their sides or backs in order to attack. There is also no chance that you can out-run or out-swim them. The safe procedure is to inspect the swimming area as thoroughly as possible and try to select a spot protected by sandbars or rocks on which you can climb entirely above the water. Fish seldom attack swimmers and statistical odds are very much against your being injured. However, there is no point in tempting fate by swimming where sharks or barracuda are visible. It's worth noting that most attacks occur when the swimmer is entering or leaving the water. This is probably because when fully immersed you appear to the fish to be his equal in size. When just an arm or leg is exposed it may appear to be the size of a convenient snack.

If, while you are swimming, sharks or barracuda approach you, head for safety at the same speed you have been moving, with no show of panic. Try to keep between the fish and the beach until you have gained a foothold. Don't attempt to put your feet on the bottom and run for it. Fish can move with lightning speed. Your safest course is to continue shoreward with your body immersed to show its full size until you can roll right upon the sand or rocks. Try never to let a dangerous fish get between you and the boat or beach. The fish may think that you present an obstacle to his path of escape. If it appears that you are blocking his free access to the open sea, he may attack without further provocation.

Scattering garbage over the side of the yacht may keep a dangerous fish attracted to your surrounding area through your entire trip. It is far wiser to wrap your waste products in bags or foil and either weight them so they sink at once or use large enough bags so the waste will flow downwind away from the boat. Remember that sharks hunt mostly by scent and taste and cannot detect objects when these objects are downwind. If a shark follows your boat when you are pulling a taffrail log, reel the log in with slow steady motions and store it on board until the fish has left. Sharks, barracuda, game fish, even including the gentle dolphin, may strike at a taffrail log. There is no expression so satisfied as that on the face of a porpoise who has just eaten one hundred dollars worth of navigation equipment.

### Emergency Repairs

Emergency repairs can ordinarily be divided into three categories: repairs to the rig or power plant, repairs to the steering gear, and repairs to the hull itself. Elsewhere in this book, as in the chapter on "Construction," details are given concerning the fabrication of the parts of a boat. Here we shall concern ourselves only with heroic measures and temporary devices by which you may be able to guide yourself to safety.



#### *Rig and Power Plant Repairs*

Failure of a shroud, stay, or rigging fitting must be dealt with quickly or your mast may go over the side. If a shroud, tang, chainplate, or turnbuckle fails, gybe the boat around at once to the opposite tack. By gybing you avoid the increase in strain upon the rig which accompanies momentary heading closer into the wind. You transfer the load upon the mast and sails to the still sound rigging on the opposite side of the boat. If this tack permits you to head for any useful harbor, continue on it to that harbor, meanwhile making such repairs as are possible to the damaged rigging.

The failure of a jibstay or headstay when a sail is carried on that stay is of little consequence so long as you are under way. The sail itself will carry the load of the spar but, if the wind is strong, you should avoid trimming the mainsail in too tightly. Sheeting hard down on the main boom puts an enormous strain along the mast of the boat and may load the jib tack or halliard fittings beyond the point for which they were designed. In strong winds or rough seas it is wise to take off the mainsail or reef it to reduce the strain. Meanwhile, if you have extra halliards for spinnakers, or additional headsails, lead them forward and lash them to a secure deck fitting, such as the sampson post, so they can act as supplemental stays. If you do not have extra halliards, lower your mainsail before you plan to lower the jib. Detach the headboard end of the mainsail halliard from the sail and make it fast to a substantial fitting on the mast, such as a secured gooseneck or a halliard winch. The hauling end of the halliard can then be led forward and secured as described before. It will make a satisfactory temporary stay.

If a mast fails or breaks above the deck it can be used as a stump from which the boom can be erected, lashing the two together strongly and staying the top of the boom as though it were a mast. The sheet blocks at the outboard end of the boom and the sheet itself can now be used for halliards on which a jury rig can be hoisted. If the mast broke above the gooseneck, this is particularly easy to do.

A mast which breaks and falls over the side of the boat should be got on deck and lashed as quickly as possible or cut free from the boat altogether and left to drift away. A floating mast, restrained by remnant shrouds or lines can become a dangerous battering ram capable of driving itself through the boat in rough weather. The quickest way to free such a fallen mast is by disarticulating the wire rigging at the turnbuckle clevis pins. Sheets and halliards should be cast off or cut free with a knife. If the sails have snagged to the boat, cut them away as well as you can, but try to save any large pieces of sail which may be used for your jury rig.

Masts which are stepped on deck and do not lead through the cabin to the keel will generally go over the side without breaking if a shroud or stay fails. Such masts can usually be saved intact. It is particularly important, however, if you have to tow such a mast to save it, that you attach a large drogue or bucket to the trailing end of the mast and tow the mast itself on a rope sufficiently long so that the mast lies two wave crests from the stern of the boat. This is protection against the mast being driven through the stern in a following sea.

If a mast breaks high above deck make every effort to secure it by the halliard so that the loose end cannot drive down and injure those aboard. With modern spars and rigging, failure or breakage is extremely rare. It can almost always be traced to neglect or carelessness in maintenance.

Detailed power-plant maintenance and care are discussed in Chapter 4, "The Engine." Here are some suggestions for emergency.

If both engines fail in a twin-engine boat, it is sometimes possible to switch around parts and components so that you end up with one functioning machine. If you have a choice as to which engine you can revive, pick the one on the lee side of the boat. There are two bonuses from this decision. First, the engine on the lee side generally has its propeller constantly in the water while that on the weather side may roll its propeller clear if the waves are large. Second, the engine on the lee side will have some of its torque, and the drag from the dead propeller will be, on the windward side, counteracted by the action of the wind and seas. Moreover, you can frequently drain the fuel from the lee tank and easily replenish it from the tank on the high side whereas it is impossible to do the reverse.

Most motorboats have little lateral resistance but they can be made to sail before and across the wind. Any sail you can rig will help you so long as the wind is not offshore. In offshore wind conditions it is best to anchor or, if off soundings, drag a sea anchor or drogue to keep your drift to a minimum. A swamped dinghy, waterlogged mattresses, or one or more buckets attached to the longest rope available will be of real assistance. You must pay out sufficient scope so that the drags lie in the trough one wave from you. The purpose of this is to keep them in relatively still water when you are in water which is moving fast.

**Steering Gear**

Every boat should be fitted with an emergency tiller. On boats having inboard rudders, this can be a piece of bent pipe to which jaws have been welded that fit over the rudder post. In the event of cable failure, gear failure, wheel failure, or steering pulley damage you will still be able to direct the rudder. On boats with outboard rudders a spare tiller is simply attached in case of damage to the regular one.



If the rudder blade itself is damaged, satisfactory steering can be accomplished with an improvised oar or by dragging a bucket on a long rope in such a manner that you can direct it to one side or the other of the stern and steer with it. A satisfactory steering oar can be fabricated from a plank of floorboard or by nailing a hatch cover to a pole, lashed to the transom of the boat, which you use as you would an oar. Twin-engine boats can usually be steered by varying engine speeds of one machine at a time or by engaging or disengaging the clutches alternately.

**Hull Damage**

In Chapter 10, in the section called "Emergency Repair of Fractured Hull," we discussed the soft patch for repairing puncture wounds to the hull. The soft patch, as its name implies, is any ample expanse of flexible material such as spare sails, mattresses, or blankets used to plug an underwater hole from the outside. When such dramatic damage occurs to a boat, the tremendous inrush of water through the puncture helps to carry the soft patch into place. The patch may be guided and retained by rope passed clean about the boat and tied across the deck from both sides. Sometimes it is necessary to direct several soft patches to the same puncture. In each case, so long as water is flowing through the hull, pressure will help to place the patch.

Patches placed from the inside of the boat against the damaged area must be retained by strong shoring or fastenings into the hull itself. Patch of this kind can be made from a plywood hatch cover or drawer bottom jammed across the damaged sight by a floor board wedged transversely in the cabin. It is not often that this type of patch can be used because puncture damage generally leaves a jagged hole, fragments of which protrude into the boat. Because of this, it is advisable to attempt the soft patch first rather than waste precious time clearing space for a patch you may not be able to apply. Sometimes a large jib, because of its triangular shape, makes the most easily controlled soft patch. You can last a moderate weight such as the lead from your sounding line to the head of the jib to help sink it. The lead line itself can be led about the boat and later used to aid in retaining the patch in position. You should attach similar lines to the tack and clew of the jib to guide it and to secure it. It is a good idea to practice and rehearse soft-patch technique so that, in the event of an emergency, you will not waste time planning your approach. In actual use the soft patch is not pulled tightly over the hull. A little slack is left in the fabric so that the water's pressure can seal it tightly and evenly around the perimeter of the puncture.

Sudden dangerous leaks occur when through-hull fittings, such as plumbing attachments, break. This failure is almost always traceable to elec-

trolysis. Immediate temporary repairs are made by driving a stick of wood, about the diameter of a broom handle and wrapped with layers of cloth, through the large holes. Smaller holes can be plugged with little tapers of soft wood firmly driven into place. If a seacock fails because of damage to the rotating part of the valve, you may have to drive your plug across the valve seat in the same direction as the rotating body lay.

A rupture in a flexible hose connection between two rigid plumbing fittings can best be temporarily repaired by wrapping with elastic electrical tape put on under tension. Failure of rigid fittings can be dealt with in the same way or manually broken off and plugged.

Because such sudden spurts of water are quite spectacular, panic may lead you first to your pump. Only rarely can you pump this water out as quickly as it comes in. Your immediate action should always be to attempt to stop the leak. Familiarize yourself with the location of every through-hull fitting on your boat. Be particularly certain you know how to reach the cockpit scupper drains quickly. These are generally the most difficult drains for access. Remember that, with a sailboat, coming about on the opposite tack may lift the damaged area above the water. It will in any case reduce the pressure of the entering stream.

Sometimes when an old boat is driven too hard, planking will loosen and the boat will start to leak. Tracing such a leak can be extremely difficult. Here, where the water is coming in more slowly than from a hole right through the hull, your bilge pump may enable you to keep ahead of the leak until you have located it. By slowing the boat to minimum speed, you reduce the strain upon the hull and give the water pressure a chance to hold the plank in place and slow the leak. Under no conditions attempt caulking from inside; this will only aggravate the wound by forcing the plank back out.

If Scuba, or skin-diving equipment, is available it may be the quickest way to locate and stop the leak. Be sure the boat is stopped and your engines are shut off so that there is no danger of the gears engaging to turn the propellers. Equip the diver with rags in long strips, a putty knife for forcing them in the seams or holes, and a rolled up large scrap of canvas about two feet on a side for soft patch. A cheap staple gun will last long enough under water for application of one soft patch. The staple gun should be attached to the diver on a lanyard so he can't lose it.

### The Bilge Pump

There is no such thing as a bilge pump that is too big. The best bilge pumps made are the simplest. The best and simplest bilge pump I've ever seen is a diaphragm pump made by Michael Henderson of Cowes, Isle of Wight, England. This pump, which can be operated by a drawstring from anywhere in the boat, is virtually clog-proof and throws a large volume of



water with very little effort. It is cheap, requires no maintenance and, even in the unlikely event that something stops it from functioning, it is instantly accessible for cleaning and instantly reassembled. It makes all other bilge pumps obsolete.

While the hose from the bilge pump should lead to the lowest part of the boat and be fitted with a large strainer at the intake end, it is wise to keep the discharge hose above waterline, if possible. By keeping the discharge hose high, you avoid having to pump against outside water pressure and eliminate one more hole through the boat. If you put a check valve in the intake and the discharge end of the pump, you will never lose your prime and you can even drain the discharge into the engine exhaust pipe of the boat without danger of exhaust fumes backing in. As with all hoses on the boat, the flexible synthetics are the best.

The best place to locate the bilge pump is in the cockpit of the boat. When sailing alone you will be able to tend it in bad weather. Don't make the mistake of thinking that because you have a metal or fiberglass boat there never will be bilge to pump. There are days when a wave coming down the companionway can provide you with plenty of work.

### Rescue by Boat

Bringing boats alongside one another in rough weather can be hazardous. This is particularly so if the boats are large. In the regatta from Buenos Aires to Rio de Janeiro in 1956, the owner of the yacht *Errante* was crushed to death when he fell between his boat and a deep-sea tug that had come alongside to pass him a tow line.

If circumstances permit, it is best to transfer people from a foundering vessel to the rescue craft by means of a rubber raft. The rescue boat should lie-to with her propellers stopped close downwind of the crippled boat. A stout line should be made fast to the raft or to the injured vessel; never to both at the same time. If the raft can carry the entire crew safely, you can then ease yourselves downwind in the shelter of your disabled boat until you reach the rescue craft.

Survivors should be helped aboard the stand-by vessel one at a time. While each survivor is going aboard, the remaining persons in the raft should stay seated. It is best if the rescue craft can pass a line about the chest and under the arms of each person to be helped aboard. This line must be left slack until the survivor is properly secured and padded or there is danger of injury from it. If the deck of the rescue vessel is more than a few feet above the water, it is particularly dangerous to try to hoist the survivor aboard by the rope. He can be swung against the hull of the rescue ship with great force, so it may be better for all survivors to remain in the raft until a smaller craft such as a lifeboat is lowered. They can then transfer to the lifeboat and be hoisted aboard with it at safe distance from

the hull of the rescue ship. When this is not feasible, as with intermediate-size rescue boats, often the best solution is to take the survivors into a lifeboat or leave them on the raft and tow them until conditions moderate. Such a tow should always be made at dead low speed. Individual life jackets should be provided for each person in the raft, or lifeboat, and a light line made fast about each person's chest, in case he is washed overboard again.

### Rescue by Helicopter

Rescue by helicopter is generally effected via basket or stretcher in which the survivors are transferred to the aircraft. Slings are used in some cases, but are less common. The helicopter pilot will generally address the survivors by loud-speaker and advise them of his rescue plan. Another means of communication is a message block. This is a soft wooden block containing a written message in the corked hole. The block generally carries a long colored streamer of ribbon to aid in locating it. When such a block is thrown within your range of vision, attempt to pick it up and read the message. Even though it does not concern you directly, it may tell you of someone in distress just beyond your horizon. Message blocks are also thrown to warn you of impending danger.

If the helicopter lowers a stretcher by which to take a disabled person from your boat, unsnap the stretcher from the hoisting cable and let the cable go free. Should you attempt to secure the cable to the boat while you are placing the victim in the stretcher, you endanger the aircraft and your entire vessel.

The best possible procedure to follow, once the injured person is in the stretcher, is to place the stretcher carefully in your raft or dinghy with another person on board to make fast the helicopter cable. Now drift the dinghy well clear of the yacht so there is no danger of the victim swinging into the boat or its rigging while he is being hoisted. The cables of the stretcher should be attached as is indicated by their colored coding. This will assure positioning of the victim so that his head is higher than his feet. Coast Guard rescue stretchers, baskets, and slings are all buoyant and will support the survivor and the equipment in the water. Each of these pieces of equipment carries written and photographed instructions for its use in English and in one other language. When the survivor is ready to be hoisted, he should make a thumbs up signal to the aircraft which will then reel him in. Be particularly careful never to make a turn of the hoisting cable about any object or part of your body. When tension is put upon the cable it will sever anything in its way. The crew member inside the aircraft is trained in the best method of bringing the survivor into the cabin. The survivor can help best by relaxing and allowing the crew man to do his work.

Sailboats, seeing a helicopter stand by for rescue, should lower and furl



their sails securely as the downdraft of air from the rotors can be quite violent. If the helicopter is equipped with floats and lands on the water, stand by at a safe distance until the rotors stop. If the rotors continue in motion, but the helicopter orders you alongside, come in with a life vest or crouched low in your dinghy or raft and do not stand up above a crouch until you are in the cabin. Take particular pains to keep clear of the tail rotors and the exhaust pipe. The exhaust pipe is clearly marked and is on the side of the helicopter opposite the cabin door.

### Signaling Devices

The best signaling devices for daytime use are dye markers, colored smoke bombs, and signal mirrors. Smoke bombs can be improvised from oil-soaked rags burned at a safe distance from the boat's fuel tank. Smoke flares, however, are available in distress signal kits. Any shiny surface will do as a signal mirror. In a real emergency, when nothing else is at hand, a bit of tin can, a shiny knife blade, or the reflector from your searchlight will do the trick. Such a signal may be visible for many miles. War-surplus signal mirrors are available and are developed especially for this task. They have a slit or bit of colored glass to assist your aiming them.

A national flag flown upside down, or any unusual signal, will be interpreted as a call of distress. The Civil Aeronautics Association publishes a code of distress message signals which you can scratch in the sand in huge letters, lay out with spars, build from stones on the shore, or paint on the top of your boat. To aid aircraft rescue, it is wise to have some area of your deck or cabin top painted yellow or blazer red.

Visual aids for night rescue include signaling with your light, S O S being dot dot dot dash dash dash dot dot dot; handheld flares, Very pistol flares, or rockets. Again, oil-soaked rags can be burned in any safe area. If you have a transmitter radio, the Coast Guard maintains a twenty-four hour distress stand-by. You can also call for help to the marine operator. As a last resort, getting on any radio band and yelling "Mayday" will give you priority over all other conversations and you can report your distress condition. You should post the frequencies for broadcasting distress to the Coast Guard or marine operator in a conspicuous place next to your radio crystal selector.

### Oil and Breaking Seas

The use of oil to reduce the violence of the crests of breaking seas is a time-honored practice. The small boat, performing rescue work in rough weather, or hove-to, riding out a storm, can make valuable use of this technique. Very little oil is needed. An oil-soaked cushion lashed to a bucket streamed up to windward of the boat will often do the trick. Sea-anchor oil cans are available commercially, and these have adjustable

petcocks to control the drip of oil. They, too, must be kept up to windward by a sea-anchor or a bucket. Under some conditions the effect can be quite magical. It may take several trials, however, to determine the distance from the boat at which the device is most effective. Remember, too, if you are lying with your stern to the wind or broadside, you must stream the oil from a direction dead to weather of you.

### Sea-anchors

A sea-anchor is any device which is used to create a drag in the water for the purpose of slowing the boat's drift. In contradistinction to ordinary anchors, the sea-anchor does not make intentional contact with the land. It remains in motion through the water, dragged by the boat but also carried by the surface currents in the same manner that the boat itself is made to drift. The value of the sea-anchor, therefore, is to resist the drifting of the boat caused by the wind. Riding just below the surface of the water, the sea-anchor is barely affected by wind action. The boat, with its large amount of above-water surface area would tend to blow more quickly downwind were it not for the friction and inertial drag of the sea-anchor. You can see, however, that the sole value of the sea-anchor is its ability to reduce wind-drift of the boat. In windless conditions, where the boat is carried by a tide or current, the sea-anchor is altogether useless.

We have not discussed the sea-anchor very much in this book because its use for small craft is questionable. If your drift absolutely must be minimized because of close-lying dangers to leeward, the value of a sea-anchor is obvious. However, the strain such a device puts upon the boat will expose you to extra dangers and increased discomfort.

When in use, the sea-anchor should be streamed from a very long scope. The line must be well secured to a particularly strong part of the hull such as the mast. Ample chafing gear will also be required where the rode passes through the chocks. A sea-anchor should always be rigged with a tripping line by which you can spill its water, enabling you to haul it aboard the boat. Any large resistant mass of materials that will ride just below the surface of the water can be used as a sea-anchor. Elsewhere in this book it is pointed out that your dinghy can be swamped and towed for that purpose. Boats with deep forefoots take particularly great punishment lying to sea-anchors by the bow. In such a boat it may be practical to throw the anchor over the stern. In this case you must securely lash the helm so the rudder cannot be damaged by the following seas.

### Man Overboard

At the cry of "man overboard," immediately gybe the sailboat or turn your motorboat hard around at the same time stationing one person to do nothing but keep his eyes on the person in the water. Most motorboats



will drift sideways faster than a person in the water. Thus, you can approach the swimmer to his windward side and drift down upon him for the rescue. Be certain your propellers are stopped. With a sailboat you may have to approach straight into the wind to kill your way and retain control. If there was time to throw a life ring or vest to the swimmer he should be secure until you pick him up. However there is no time to waste when he may be injured or unconscious.

As you circle back to the swimmer, make ready your life raft or dinghy so that, if you cannot maneuver the large boat, you can effect the rescue from the tender. Be careful not to injure the swimmer in getting him aboard or to jeopardize other people while helping him. Under no circumstances leave the boat to help the swimmer. All you will be doing is multiplying the number of rescues to be effected. Treat each survivor as if he were shocked and injured until you know such is not the case. Crew members on deck at night should each be fitted with a waterproof signal flashlight clipped to their garments. These are available from war surplus and are very inexpensive. Crew members should also carry whistles to help attract attention in the dark.

### When to Abandon Ship

The only two times to consider abandoning ship are when you see that the vessel is sinking beyond any doubt and when she is on fire and there is danger of explosion. In each of these cases you should abandon ship at once. Delay to save your gear, to fight a full-fledged blaze, or to risk explosion is psychotic.

To abandon your boat at any other time takes considerable deliberation. If the boat is strongly built and undamaged, it will be as safe in any storm as your raft itself except for swamping. Swamping is rare but the sea conditions under which it is possible can also turn over a raft or dinghy. If the boat leaks so badly that you cannot maintain the exertion to keep her pumped, and all your efforts to stop the leak have failed, abandonment is your only choice. However, if there is still a chance of running her into shoal water where she may be later salvaged, you should consider this possibility. Once you have abandoned your vessel you have surrendered all your rights to her against public salvage.

It is also of primary importance to stay with your boat as long as possible because it will be more easily spotted by rescue searchers than a smaller object. Although the boat be completely disabled, if it is still in floating condition it will provide you with protection against the elements. Probably, too, you will still have usable fresh water in the tanks on board and this is important to your survival. If you must abandon ship, and have sufficient time, here are the things you should take with you in the dinghy or life raft.

1. Canteens of water, tinned fruit juices, or tinned soups
2. Food of any kind
3. Can opener
4. Warm clothing
5. Dry matches, or other means of starting a fire
6. Knife
7. Foul-weather gear
8. Flashlight
9. Compass
10. Chart

In these ten items you have the makings of signaling devices, either knife blade or the tins. You have food and water for survival. You have protection against the elements. You have equipment to build simple shelter on shore. You have the means to plot a course to safety if your dinghy or raft finds a favorable wind.

The least desirable way to abandon ship is with the life jacket alone. Your body, immersed in the sea, begins to dehydrate and feel the cold. There is also a serious danger of attack from sharks and barracuda. In these days of skin diving, there is a tendency to scoff at the danger of fish attack. Nevertheless, a study of statistics of such attacks will thoroughly convince you that you must keep your body out of the water if it is at all possible.

The loss of a small boat to the sea is a truly rare event. While it is important that you know how to deal with the situation, there is hardly any chance that you will ever encounter it.

# Appendixes

## Appendix A

CHARACTERISTICS OF SMALL MOTOR CRAFT

| Boat Type | Bottom | Approx. Weight | Outboard Horsepower | Average Max. Speed |
|---|---|---|---|---|
| 18' Canoe Square End | Round Displacement | 80 lbs. | $3\frac{1}{2}$ | 4 to 6 mph |
| 9' Dinghy | Round Displacement | 85 " | $3\frac{1}{2}$ | 5 to 7 mph |
| 10' Cartop | Round Displacement | 100 " | 5 | 7 to 9 mph |
| 12' Utility | Round Semi-Displ. | 150 " | 12 | 18 to 22 mph |
| 14' Runabout | V-Type | 225 " | 25 | 26 to 30 mph |
| 16' Utility | V-Type | 350 " | 25 to 40 | 27 to 31 mph |
| 16' Runabout | V-Type | 385 " | 25 to 40 | 28 to 32 mph |
| 20' Cruiser | V-Type | 1500 " | 50 or 2 25's | 26 mph |

## Appendix B

WEIGHTS OF CONVENTIONAL ANCHORS

| Size of Boat | Regular Anchor | Storm Anchor | Mooring Mushroom Anchor |
|---|---|---|---|
| 20 ft. | 15 lbs. | 30 lbs. | 150 lbs. |
| 25 " | 25 " | 50 " | 200 " |
| 30 " | 30 " | 60 " | 250 " |
| 40 " | 40 " | 75 " | 400 " |
| 50 " | 50 " | 100 " | 600 " |

Note: These anchor sizes do not apply to the varieties of modern anchors such as CQR plows, Bensons, and Danforths. Use manufacturers' recommendations for these anchors.

Note: The holding power of any anchor is greatly improved by the use of one or two fathoms of lightweight chain between the anchor and the line. The anchor line should be of nylon rope.



## Appendix C

U.S. COAST GUARD MOTORBOAT EQUIPMENT REGULATIONS

| Equipment | Class A 0' to 15'11" | Class 1 16' to 25'11" | Class 2 26' to 39'11" | Class 3 40' to 65' |
|---|---|---|---|---|
| Combination light: | 1 in fore part of boat, red to port, green to starboard—must be visible at least 1 mile from dead ahead to 2 points abaft beam on both sides. | | | |
| Individual port and starboard lights: | | | Visible for at least 1 mile—red on port side, green on starboard and visible from dead ahead to 2 points abaft beam on both sides. | |
| Bow light: | | | 1 bow light in forward part of boat, visible at least 2 miles showing from dead ahead 2 points abaft beam on both sides. | |
| Stern light: 1 stern light visible at least two miles showing all around horizon. | | | | |
| Whistle: | | 1 hand, mouth or power—audible $1/2$ mile. | 1 hand or power—audible 1 mile. | 1 power operated—audible 1 mile. |
| Bell: | | | 1 bell, clear and audible. | |
| Lifesaving devices: | 1 life preserver, ring buoy or buoyant cushion for each person aboard. | | 1 life preserver or ring buoy for each person aboard. | |
| Fire extinguishers: | One 1 qt. carbon tetrachloride or one $1\frac{1}{4}$ gal. foam or 1 $CO_2$ five-pound extinguisher. | | Two 1 qt. carbon tetrachloride or two $1\frac{1}{4}$ gal. foam or 2 five-lb. $CO_2$ extinguishers. | Three 1 qt. carbon tetrachloride or three $1\frac{1}{4}$ gal. foam or 3 five-pound $CO_2$ extinguishers. |
| Flame arrestors: | One on each carburetor of each engine burning gasoline and installed after April 25, 1940. | | | |
| Ventilation: | At least two ventilators with cowls or their equivalent capable of removing gases from the bilge in engine and fuel tank compartments of boats constructed or decked after April 25, 1940, and using gasoline or other fuel of a flashpoint less than 110° F. | | | |

## Appendix D

WEIGHTS OF MUSHROOM ANCHORS

(Assume 30 ft. depth of water, 3 fathoms of chain on anchor)

| TYPE OF BOAT | Overall Length of Boat 20 | 25 | 30 | 35 | 40 | 45 | 50 |
|---|---|---|---|---|---|---|---|
| SAIL | 100 | 150 | 175 | 200 | 250 | 300 | 350 |
| MOTOR | 150 | 250 | 275 | 300 | 350 | 400 | 450 |
| AUXILIARY | 150 | 200 | 225 | 250 | 350 | 400 | 500 |

## Appendix E

TENSILE STRENGTHS OF ROPES

(in pounds)

| Diameter | Nylon | Italian Hemp | Manila |
|---|---|---|---|
| 5/32" | 650 | 480 | 220 |
| 1/4" | 1200 | 1010 | 500 |
| 5/16" | 2020 | 1340 | 1200 |
| 7/16" | 3220 | 1680 | 1570 |
| 1/2" | 4480 | 2350 | 2350 |
| 5/8" | 8060 | 4140 | 4480 |
| 1" | 17900 | 9410 | 10080 |



## Appendix F

BREAKING STRENGTHS OF RIGGING WIRE

STAINLESS-STEEL RIGGING WIRE—1 × 19

| Diameter | | Diameter | |
|---|---|---|---|
| 3/32" | 1000 lbs. | 3/16" | 4500 lbs. |
| 1/8" | 2000 " | 7/32" | 6000 " |
| 5/32" | 3000 " | 1/4" | 9000 " |

GALVANIZED-IRON RIGGING WIRE—6 × 7

| Diameter | |
|---|---|
| 1/8" | 420 lbs. |
| 3/16" | 1220 " |
| 1/4" | 1980 " |
| 5/16" | 2720 " |
| 3/8" | 3900 " |

GALVANIZED-IRON RIGGING WIRE—6 × 19

| Diameter | |
|---|---|
| 1/4" | 2200 lbs. |
| 5/16" | 3200 " |
| 3/8" | 5000 " |

STAINLESS-STEEL RUNNING RIGGING—6 × 24

1/4" circumference breaks at 400 lbs.

---

(A) The total strength of the main shrouds on one side of a boat should equal the weight of the boat.
(B) A splice will yield about 80% of the breaking strength of the wire.
(C) Swaged terminal fittings will yield 100% of the breaking strength of stainless-steel wire.

## Appendix G

### 3M ALUMINUM OXIDE PRODUCTION PAPERS

| Very Fine | Fine | Medium | Coarse | Very Coarse |
|---|---|---|---|---|
| 400-10/0 | 180-5/0 | 100-2/0 | 50-1 | 36-2 |
| 320-9/0 | 150-4/0 | 80-1/0 | 40-1½ | 30-2½ |
| 280-8/0 | 120-3/0 | 60-1/2 | | 24-3 |
| 240-7/0 | | | | 20-3½ |
| 220-6/0 | | | | 16-4 |
| | | | | 12-4½ |

**Grit symbols** run from 4½, which is the coarsest, to 10/0, which is finest.
**Mesh numbers** refer to the number of openings per lineal inch on a standard control screen. Number 12 is the coarsest; number 600 is the finest.



## Appendix H

### WEIGHTS AND QUALITIES OF WOODS
(in diminishing order of strength)

| Type | Wt. Per Cubic Ft. | Qualities |
|---|---|---|
| Locust | 50 | Rot resistant; hard to fiberglass. |
| Lignum Vitae | 78 | Hard, self-lubricating, worm resistant, strong and stiff. |
| White Ash | 42 | Cannot be fiberglassed. |
| White Oak | 48 | Steam bends well; must be washed with lye solution before fiberglassing. |
| Yellow Pine | 45 | Very rot resistant; must be washed with lye before fiberglassing. |
| Cuban Mahogany | 40 | Hard; sand cross grain before fiberglassing. |
| White Elm | 37 | Scrubs very white; can be used unfinished. |
| Douglas Fir | 37 | Hard; makes good planking; takes fiberglass particularly well. |
| African Mahogany | 38 | Strong; water resistant; sand cross grain before fiberglassing. |
| Teak | 45 | Very resistant to rot and worms; must be washed with lye before fiberglassing. |
| Larch | 38 | Makes excellent knees and breasthooks. |
| Mexican Mahogany | 35 | Very stable; fine appearance; sand cross grain before fiberglassing. |
| Cypress | 35 | Rot resistant; has some odor; hard to fiberglass. |
| Philippine Mahogany | 39 | Quality varies greatly; sand cross grain before fiberglassing. |
| Northern Spruce | 25 | Good for spars; takes fiberglass very well. |
| Sitka Spruce | 26 | Good for spars; takes fiberglass very well. |
| Port Orford Cedar | 28 | Excellent for planking; shrinks and swells, is difficult to fiberglass. |
| Northern Pine | 27 | Especially good for patterns and models. |
| Spanish Cedar | 24 | Good for planking. |
| White Cedar | 21 | Good for planking; very soft. |

## Appendix I

FRAMES, PLANKING AND FASTENINGS FOR CAULKED WOODEN BOATS USING BRONZE OR MONEL SCREWS

| Overall Boat Length | Planking Thickness | Frame Spacing | Frame Size | Screw Gauge | Screw Length |
|---|---|---|---|---|---|
| 10' | 1/4" | 6" | 5/8" | 6 | 1/2" |
| 20' | 1/2" | 9" | 1" | 8 | 1" |
| 30' | 3/4" | 10-1/2" | 1-3/8" | 10 | 1-1/2" |
| 40' | 1" | 12" | 1-3/4" | 14 | 2" |

## Appendix J

WEIGHTS OF METALS PER CUBIC FOOT

| | | | |
|---|---|---|---|
| Aluminum Alloys | 169 lbs. | Copper | 550 lbs. |
| Brass | 530 " | Lead | 711 " |
| Bronze | 545 " | Magnesium Alloys | 113 " |
| Cast Iron | 450 " | Monel | 558 " |



## Appendix K

RESINS AND THEIR CHARACTERISTICS

| | Reaction to Heat | Mechanical Properties | Electrical Properties | Water Resistance | General Remarks |
|---|---|---|---|---|---|
| **Epoxies** | slow burning | very strong—thermosetting | good insulator | excellent | best resin for high-strength boat work—some amine catalysts are very toxic—low-toxic catalysts are available |
| **Polyesters** | slow burning obtainable as self-extinguishing, e.g., Hetron 90 | very good for general boat use—thermosetting. | good insulator | satisfactory | shrinks 5% to 8% upon curing—very uniform and dependable handling characteristics—wide choice of characteristics |
| **Phenolic** | self-extinguishing | very good—thermosetting | fair insulator | satisfactory | poor color possibilities—wide general use—low cost—good molding resin |
| **Polystyrene** | burns poorly | satisfactory—thermoplastic | good insulator | excellent | low cost, very light-weight filler material—very poor heat resistance—good for buoyancy chambers—easy to work |
| **Polyvinyl Chloride** | burns slowly | very good—thermoplastic | fair insulator | very good | available in excellent castings for plumbing, light-weight structural fittings |

## NONFERROUS METALS AND THEIR CHARACTERISTICS

| | |
|---|---|
| Brass: | Satisfactory metal to use for general hardware inside and for hinges, door and hatch fittings outside. Completely unsatisfactory in salt water. Electrolyzes easily. |
| Naval Brass: | Strong, easy to work, machines cleanly. Does not seem to electrolyze by itself in salt water, but will electrolyze in presence of current or higher metals. |
| Copper: | Stands up well in salt water. Very malleable and easy to work except for machining. A soft metal, copper rivets and nails sometimes stretch under load. |
| Gun Metal: | Strong, easy to cast and machine. Excellent characteristics in salt water. |
| Everdur: | A high copper content bronze. Extremely corrosion-resistant. Very strong, easy to machine and cold forge. Excellent material for fastenings. |
| Monel: | Called the "Seagoin'" metal, Monel is a superb material alloyed of copper and nickel. Makes finest fastenings, tangs, chain plates and shafts. Casts well, forges well and can be welded to 100% strength. |
| Phosphor Bronze: | High strength copper-tin alloy. Fine sheet metal, resists fatigue from "working." Difficult to machine. |





## ROPE KNOWLEDGE

The following information, from *Rope Knowledge for Riggers,* is reprinted through the courtesy of the Columbian Rope Company, Auburn, New York.

### Definitions

Terms employed in knot tying:

**"Bight"** — this is formed by simply bending the rope and keeping the sides parallel (Fig. 1).

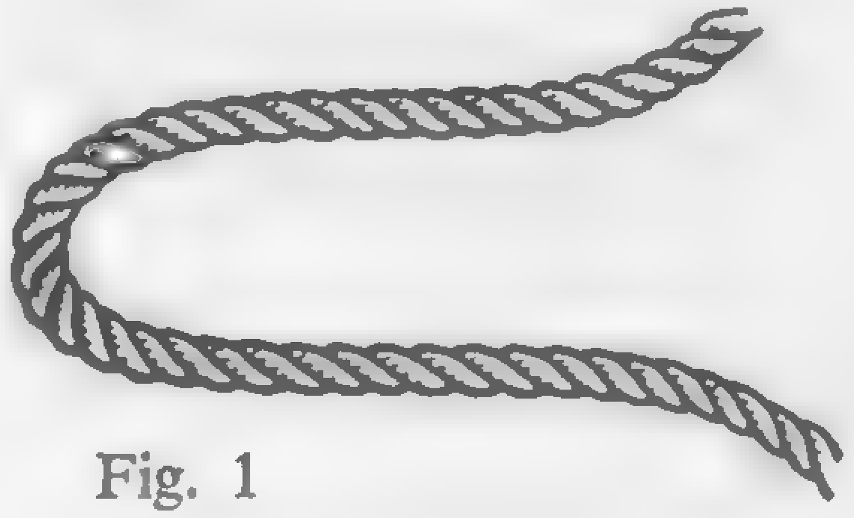


Fig. 1

Fig. 2

**"Loop" or "Turn"** — this is formed by crossing the sides of a bight (Fig. 2).

**"Round Turn"** — consists of further bending one side of a loop (Fig. 3).

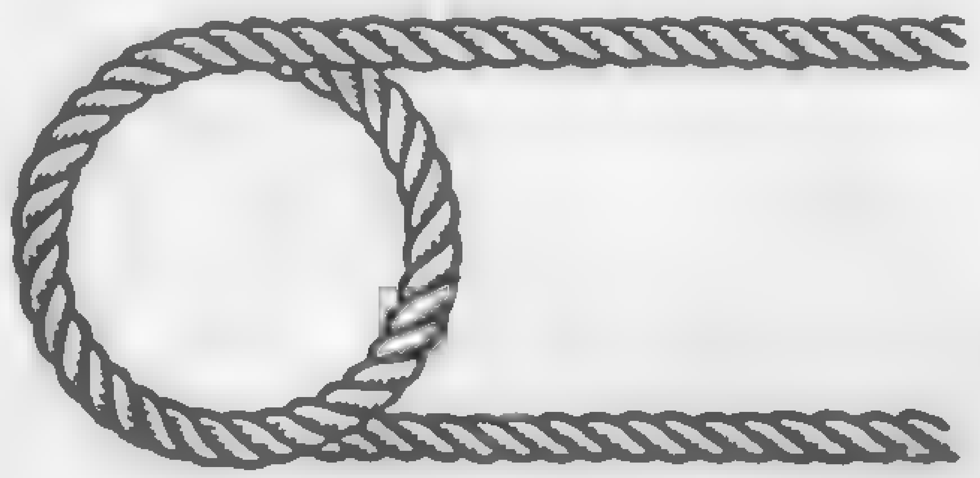


Fig. 3

**"Standing Part"** — that part of a rope which is not used in tying a knot; the long unused part which is worked upon.

**"End"** — as the name implies, the very end of the rope.

### Hand Coiling

Always coil a rope when you have finished using it. The correct method is to coil a rope with the sun, that is clockwise, or to the right as shown in Fig. 4. This is because of the twist imparted to the rope in manufacture. However, if the rope tends to kink when coiling this way, it is because a reverse twist has been imparted to the rope in use and to take out this twist, the rope must be coiled counterclockwise.

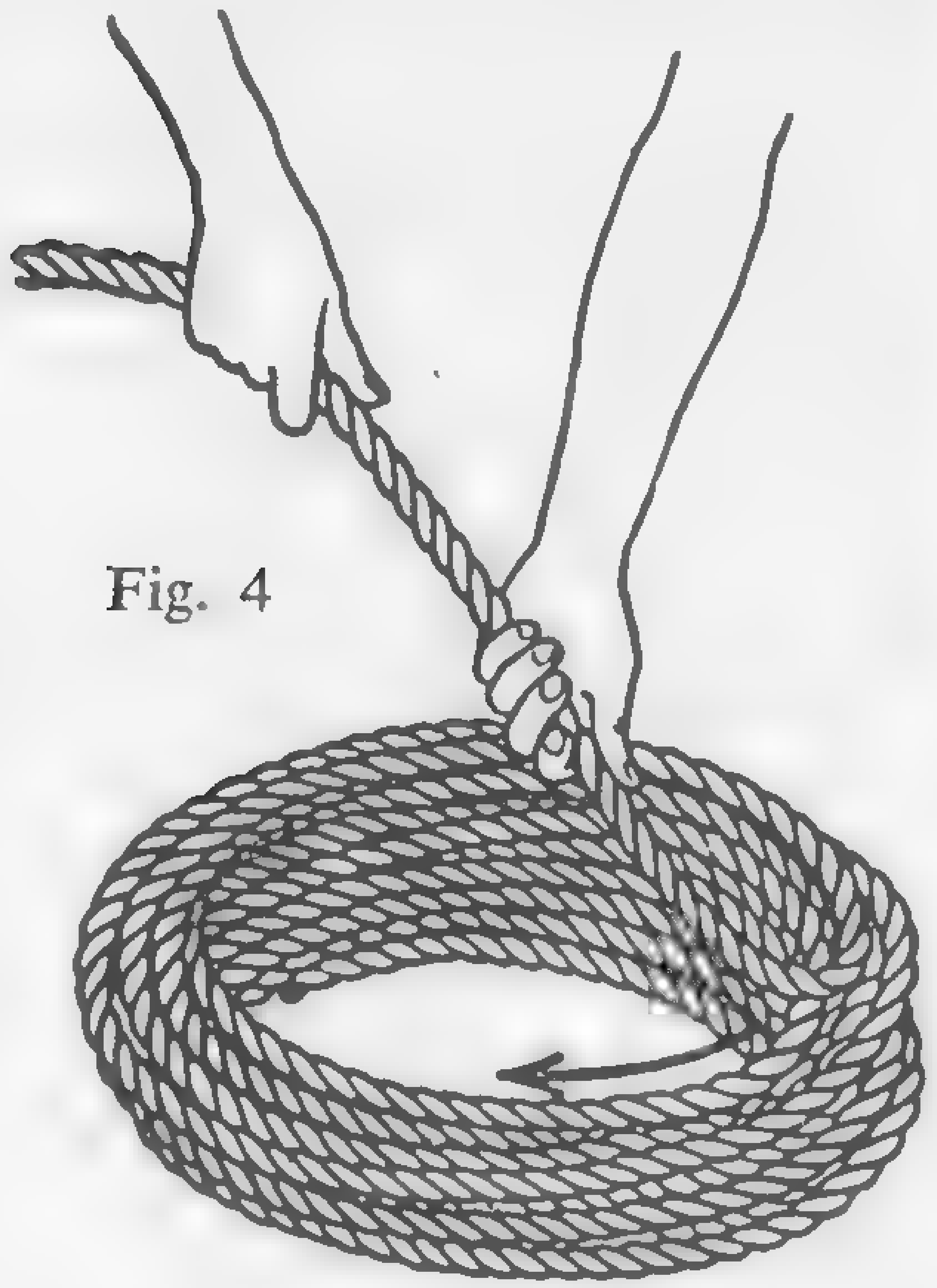


Fig. 4

### Whipping

Make a loop, C, in a piece of twine by crossing ends A and B at D. Then with your thumb on the twine at point D, begin winding very tightly and evenly around the rope toward the loop.

Then place end B through loop C. Pull on end A until the loop is about halfway through your whip. This will tighten the whip and secure end B. Cut off the ends close to the rope.

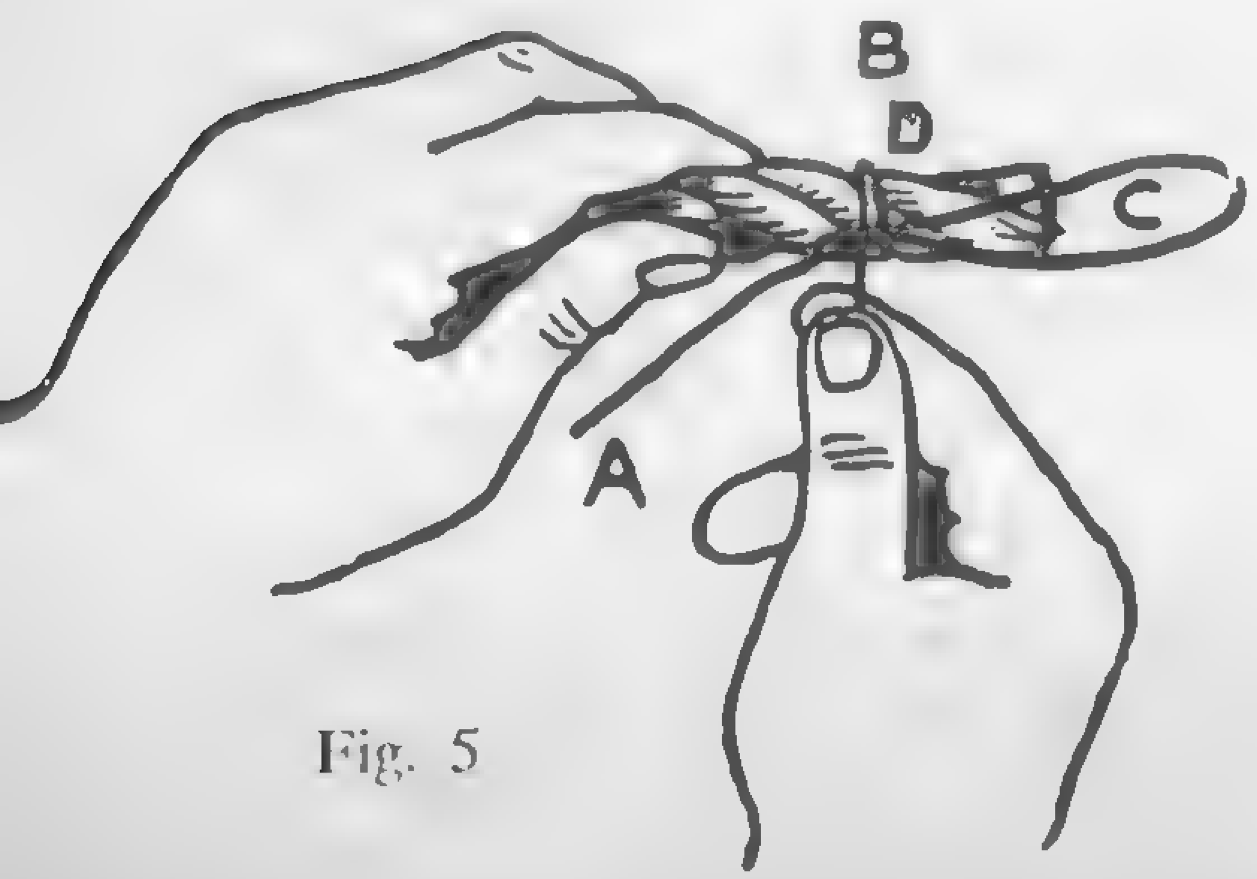



Fig. 5


Fig. 6



### The Overhand Knot

Take end A in your left hand and B in your right. Cross B in front of A, at point C, and double B under A. Then draw the two ends out in opposite directions but on the same straight line. You will note that ends A and B have changed places.

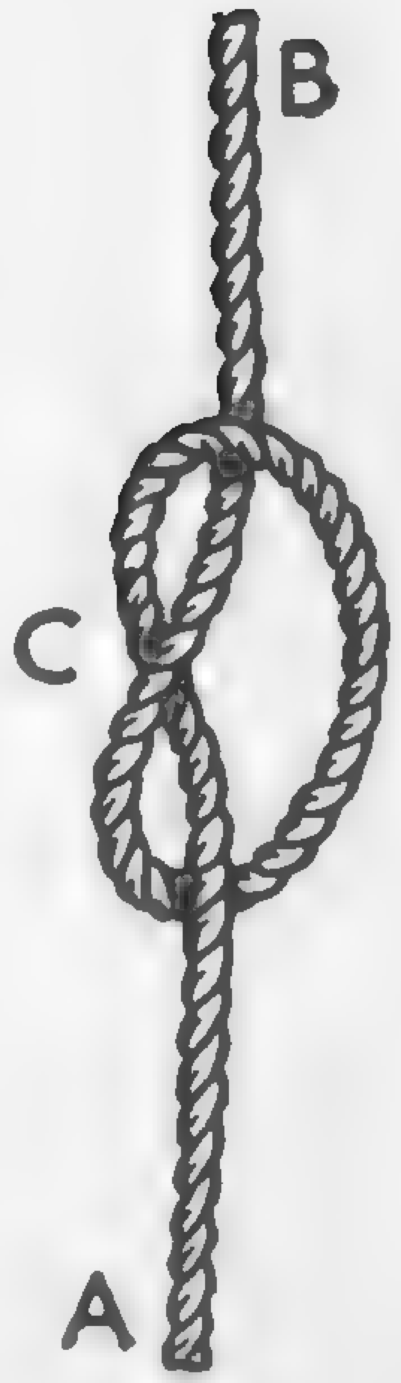



Fig. 7

### Figure Eight Knot

First make a bight and lead the A down and across B. Then pass end A up in back of the bight and through it, forming a design similar to the arabic 8.

This knot is sometimes called the perfect knot. It is used extensively by sailors to keep ropes from running through blocks or rings.

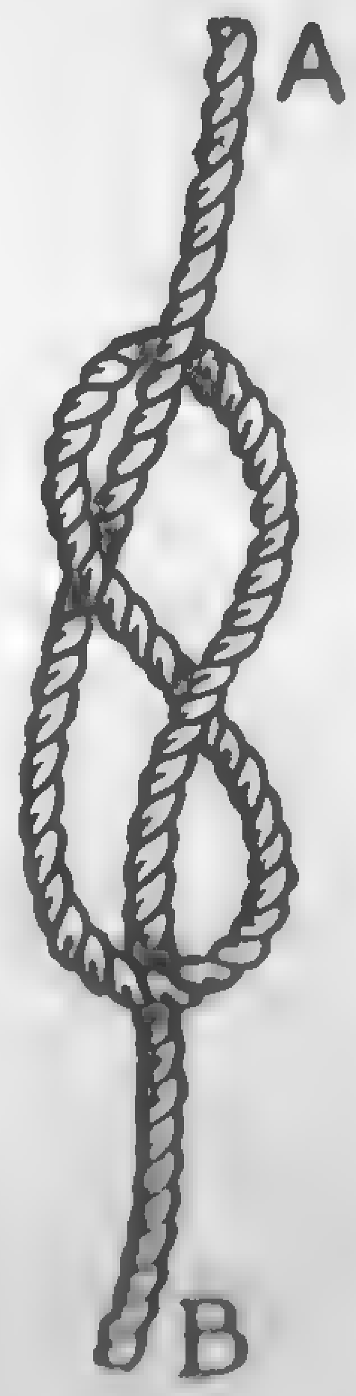



Fig. 8

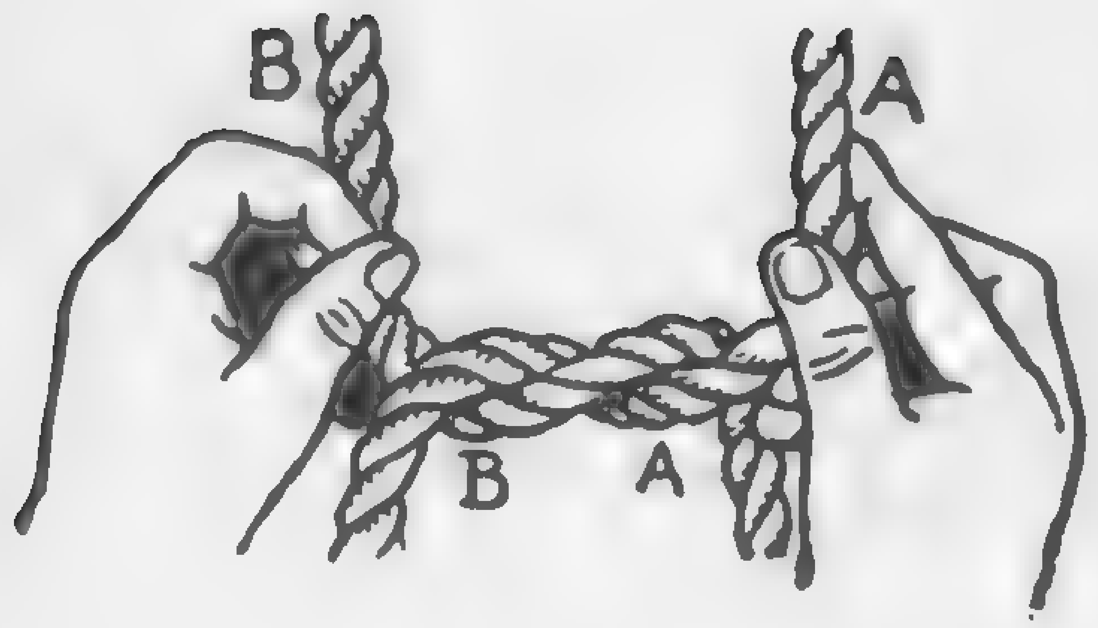



Fig. 9

**The Square Knot**

The square knot is used especially for joining two pieces of twine or small rope. It is a simple knot to tie, yet it is very strong, for the harder it is pulled, the tighter it grips.

In Fig. 9 the end A is passed over and under B.

In Fig. 10, B is passed over and under A. Then draw up both ends and you will have the square knot illustrated in Fig. 10.

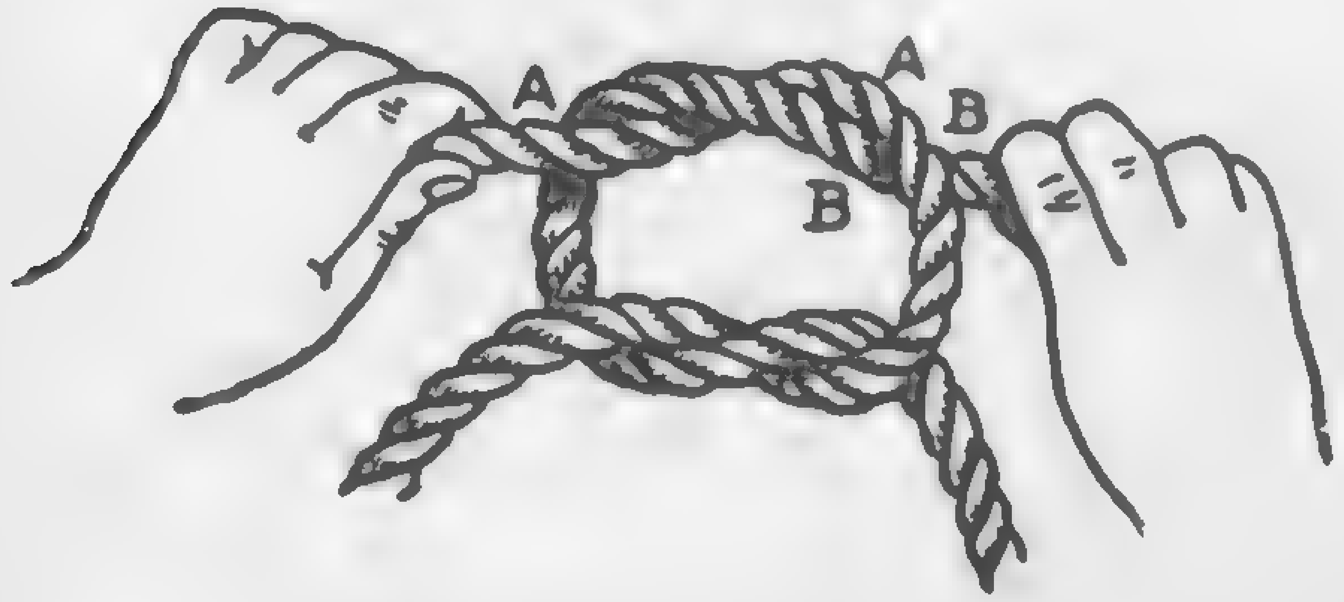



Fig. 10



**False or Granny Knot**

When making a square knot, if the ends are not crossed correctly, that is, if the ends are not parallel to the rope, the knot becomes a false reef or granny knot. Compare this knot with Fig. 10 to note the variation.

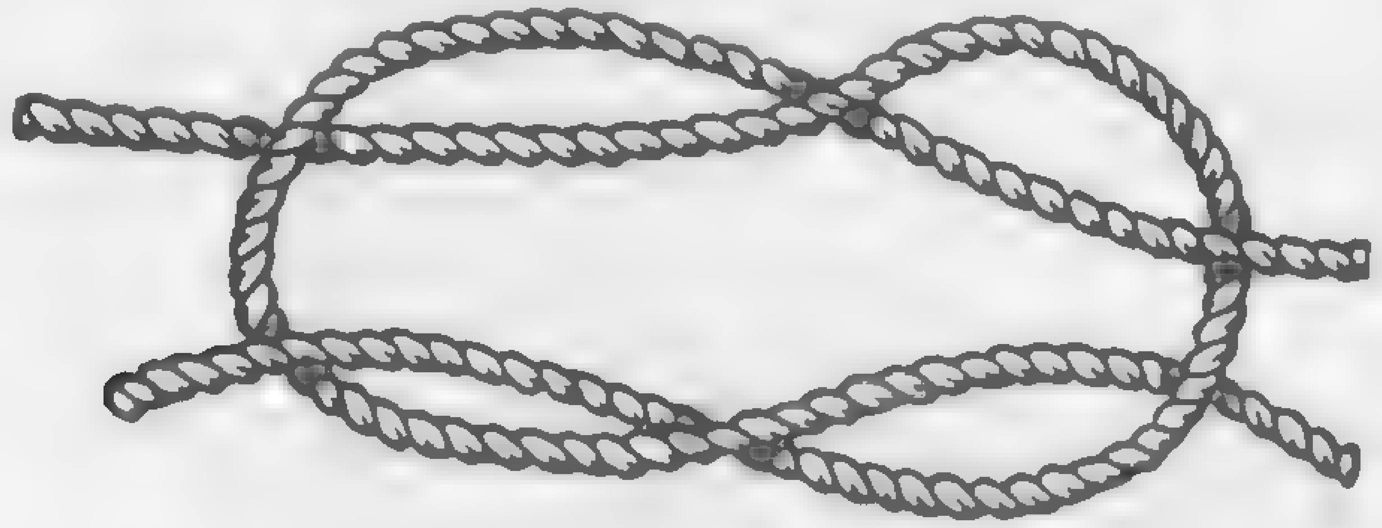


Fig. 11

**Stevedore's Knot**

The stevedore's knot is tied the same as the figure eight knot (Fig. 8), except that two turns are taken around the rope instead of one. By inserting a small stick or shackle, the knot can be easily untied.

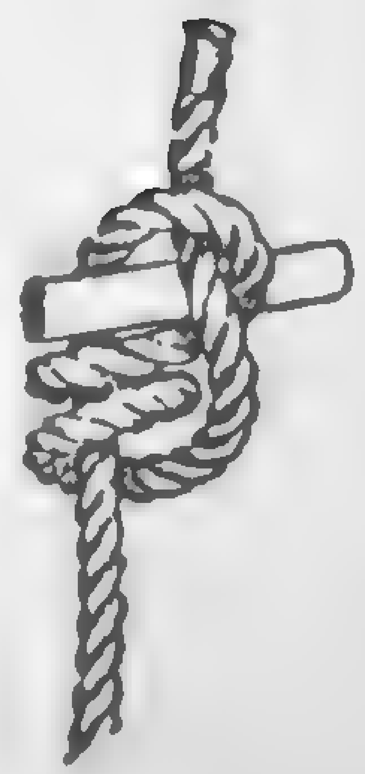


Fig. 12

### The Bowline

The bowline is a knot that can neither slip nor jam and is used for lowering a person to do some particular work.

Make a loop with the standing part of the rope underneath. Pass the end from below through the loop over the part around the standing part of the rope and then down through loop C. The length of the bight depends upon the purpose for which a knot is required.

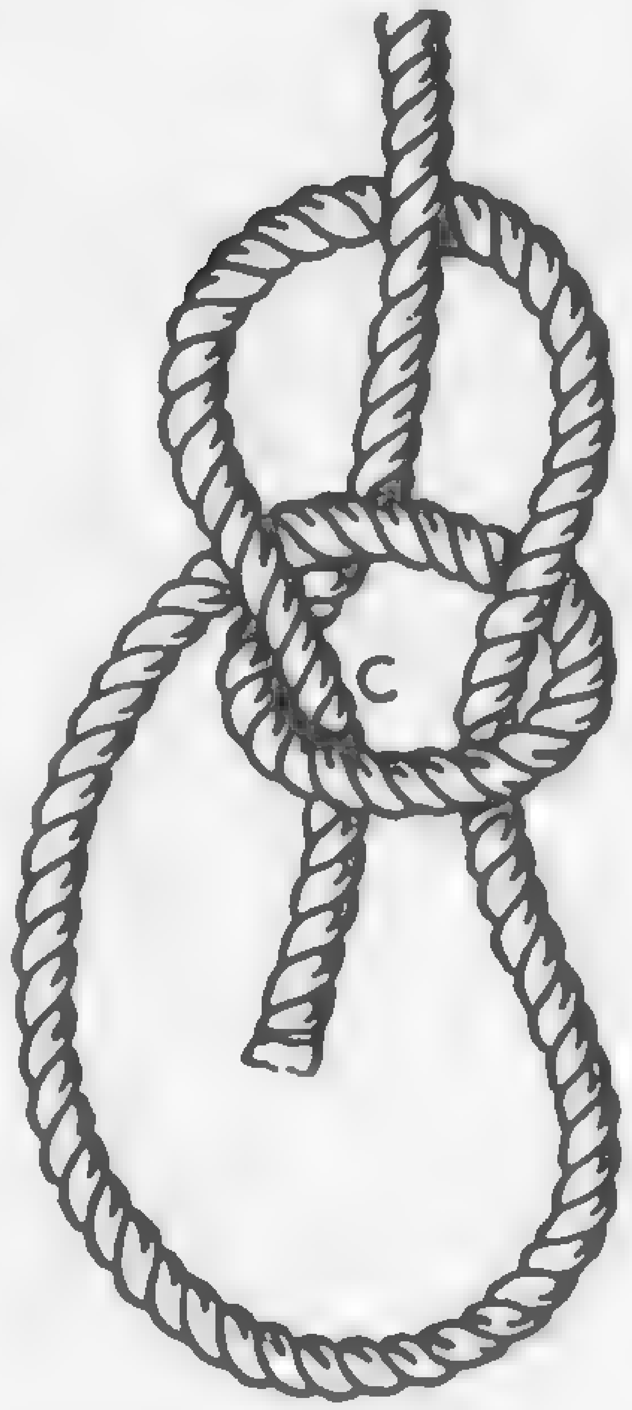



Fig. 13

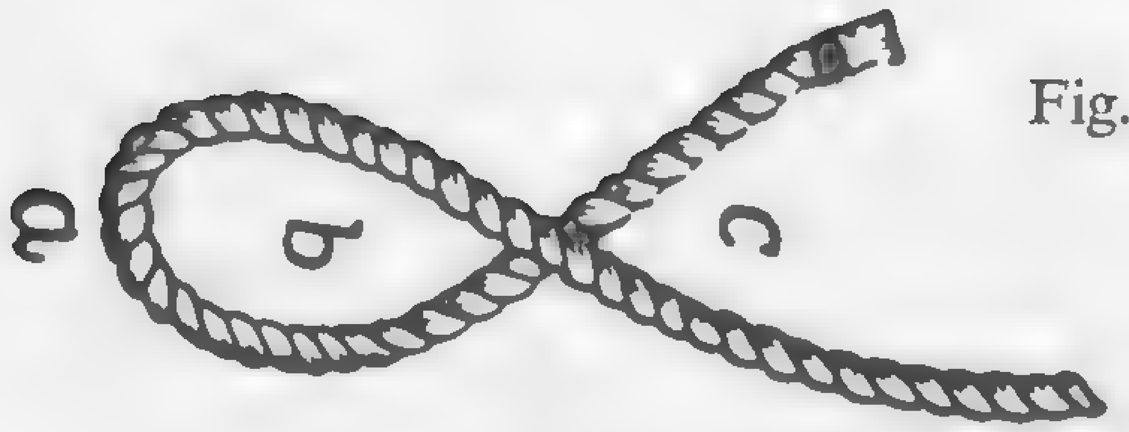
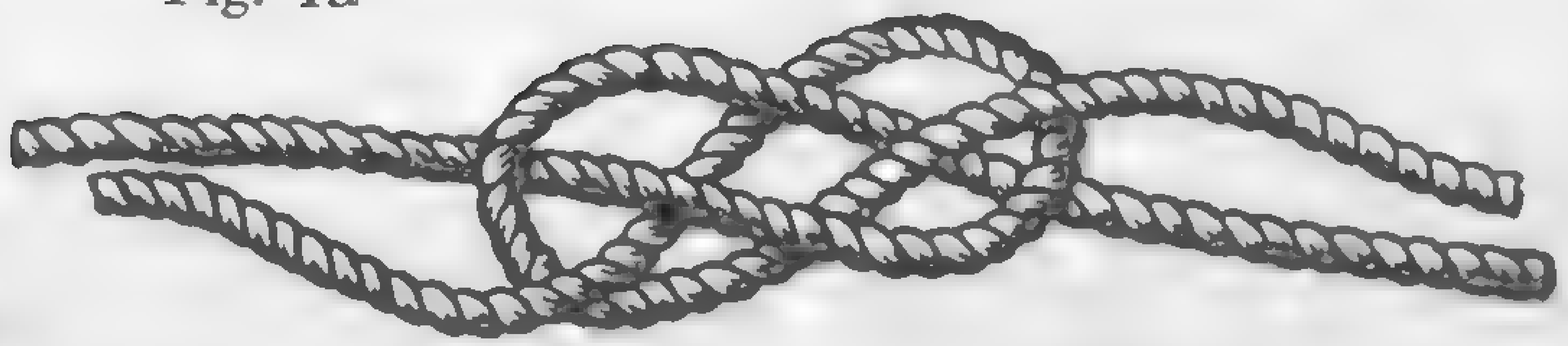



Fig. 14

Fig. 15



### Carrick Bend

The Carrick Bend is used for uniting two hawsers, especially when required to go around a capstan.

First loop is formed as in Fig. 14. Then pass the other hawser under the first at A and draw it through B. Back it over C and bring it up again through B as shown in Fig. 15.



### Two Half Hitches

Two half hitches are used for making fast the ends of a rope around its own standing part. In Fig. 16, end B of the rope AB is passed under a ring. Then it is passed first under and then over the standing part. The half hitch is then repeated in making the two half hitches.


Fig. 16

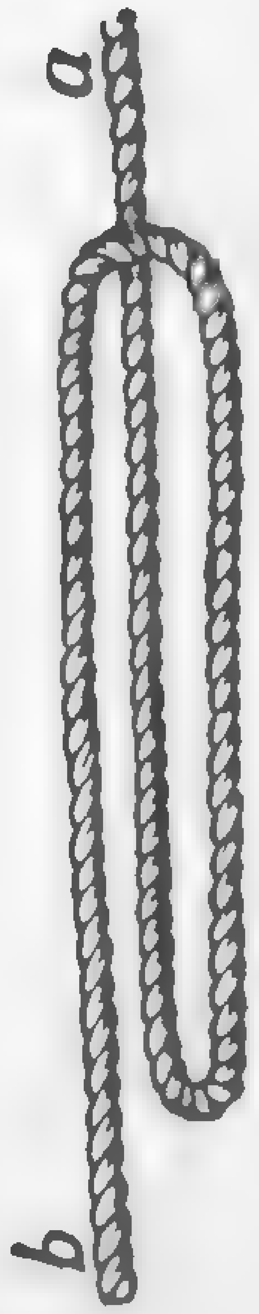



Fig. 17


Fig. 18

### The Sheep Shank

The sheep shank is used for shortening ropes which will require lengthening again. Take up the amount necessary to shorten the rope as in Fig. 17. Then using A and B make a half hitch with the standing part around the bight as in Fig. 18.

**Timber Hitch**

The timber hitch is used for hauling and lifting spars or loading light cases, bales, etc., on a ship. It is tied very quickly and is easily loosed when the strain is taken off. Yet it is a dependable knot which will not slip under a pull. It is formed by taking a half hitch and leaving a long end. This end is then passed around the standing part two or three times.

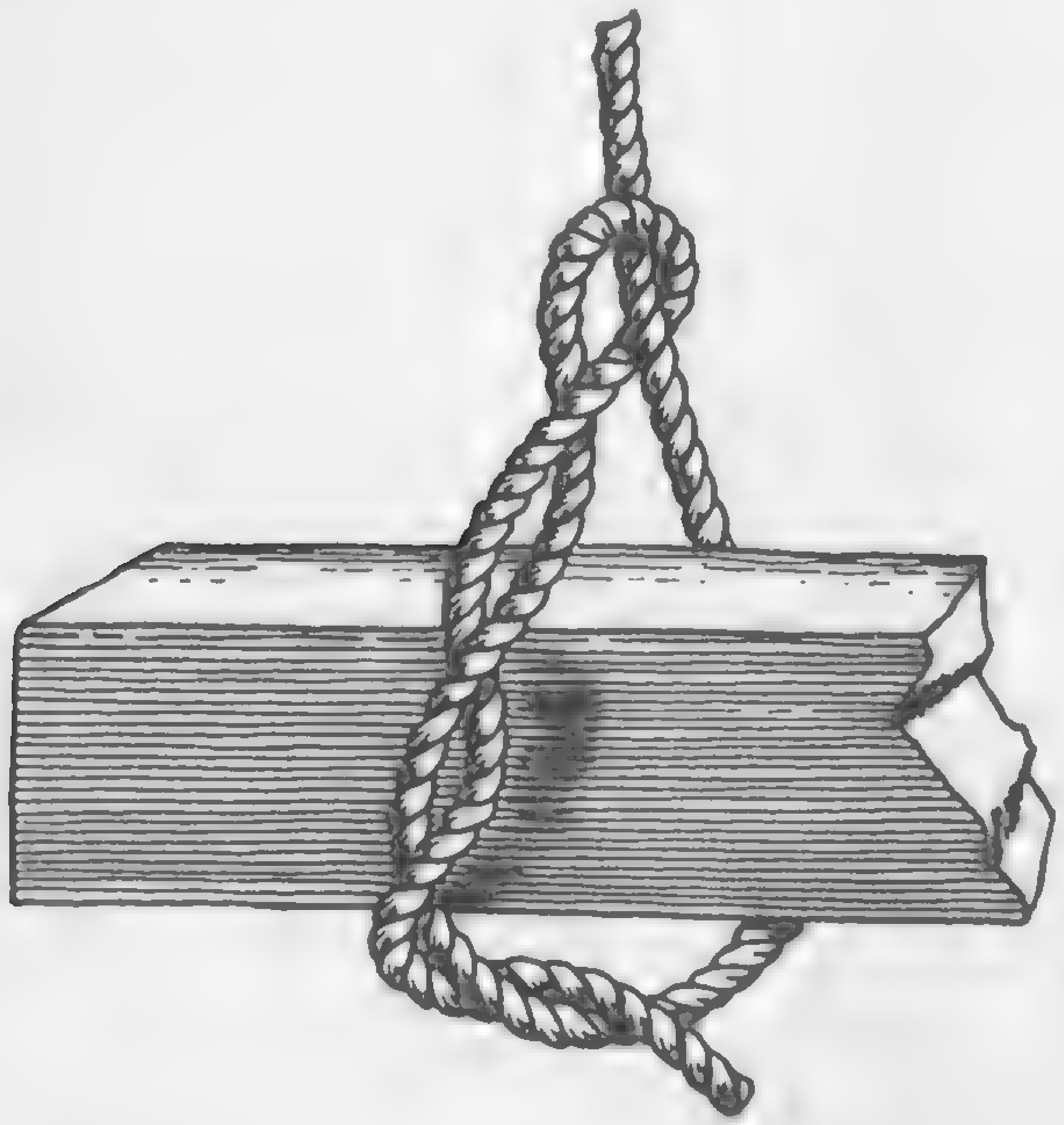


Fig. 19



**Clove Hitch**

There are many uses for the clove hitch from nautical to surgical but the most interesting is perhaps the attaching of one pole to another.

It is made very easily by holding the standing part in the left hand and passing the rope around the pole, bringing it back across the standing part at A. Then make an opposite turn around the pole and pass the ends under the last turn at B.

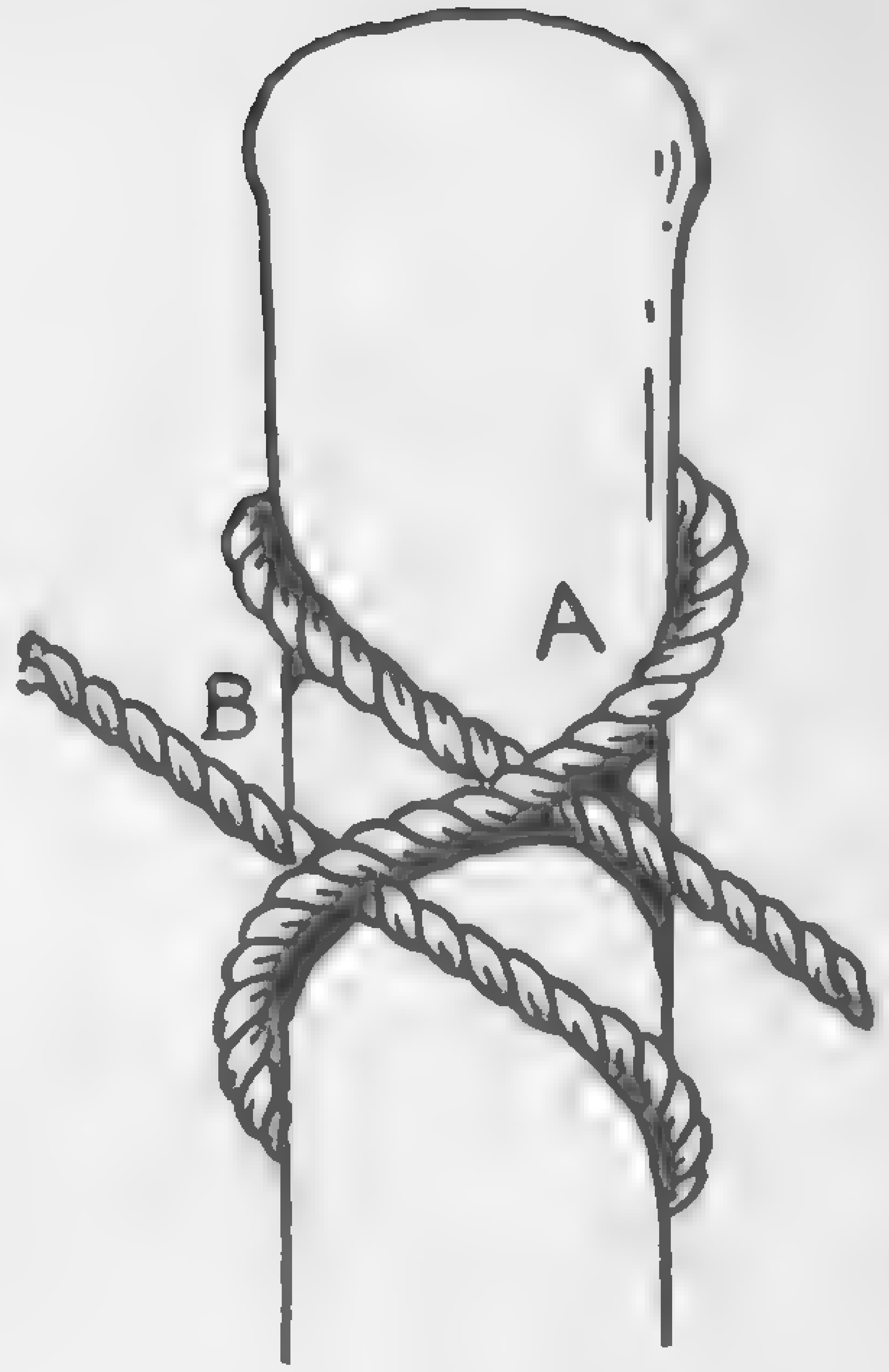



Fig. 20

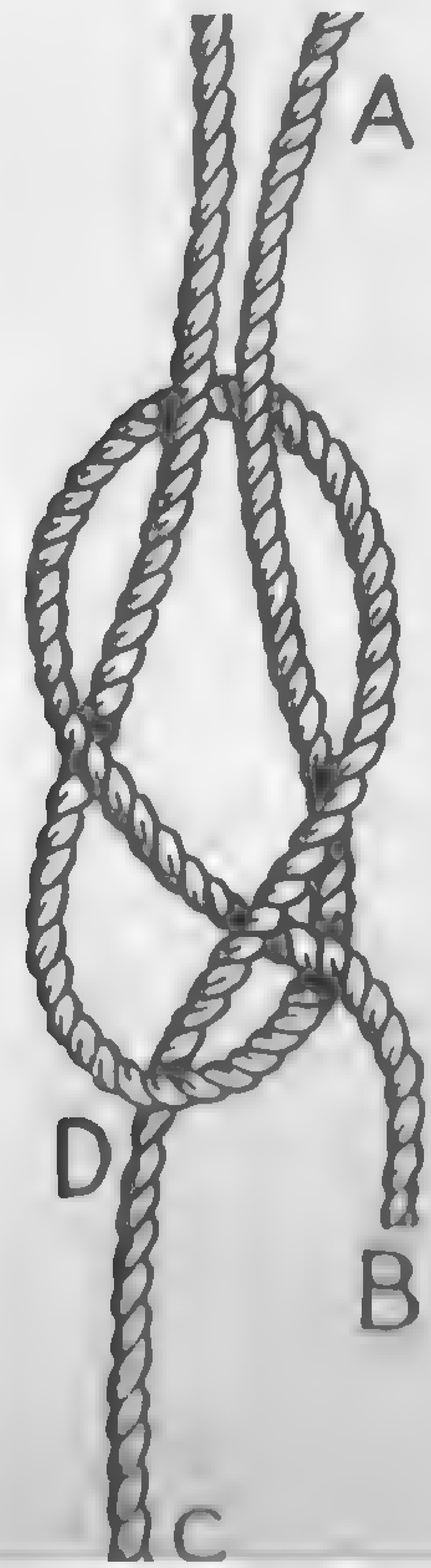



Fig. 21

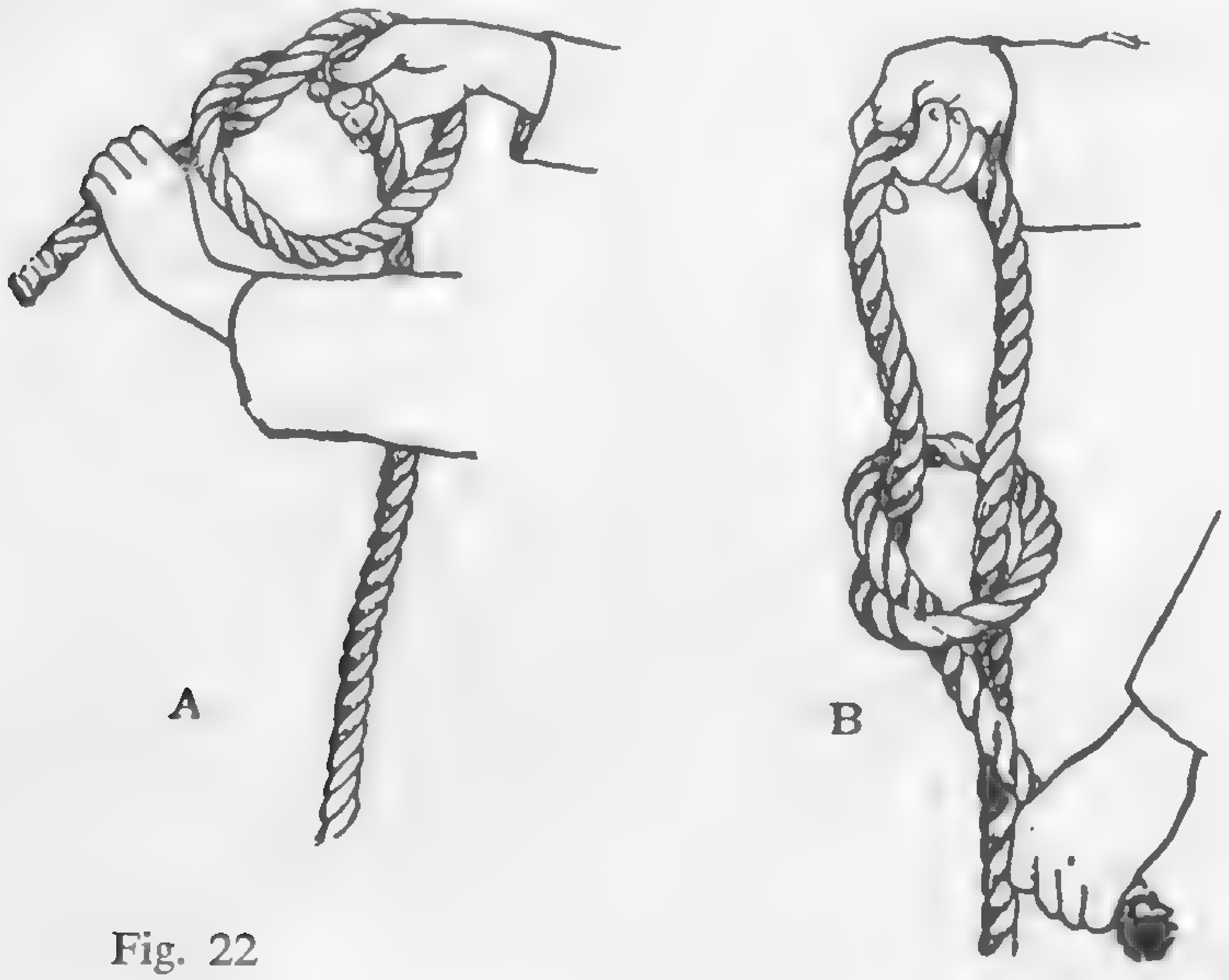
**Sheet Bend or Weavers Knot**

The sheet bend or weavers knot is generally used for joining ropes of unequal size together. It is safer and more secure than a reef knot but a little more difficult to tie.

Make a loop or bight with your rope A. Then pass end B of the other rope around and in back of the bight, formed by rope A. With end C cross over end B on the inside of the bight, and under A at point D. Then hold the rope taut.

### Slip Knot

The slip knot is the most simple slip loop to tie. Starting with the position shown in Fig. A, the end is held in the left hand and the loop is formed by twirling the rope to the right between the thumb and the fingers of the right hand. Note loop in right hand and end in left, in Fig. B.



A

B

Fig. 22



Fig. 23

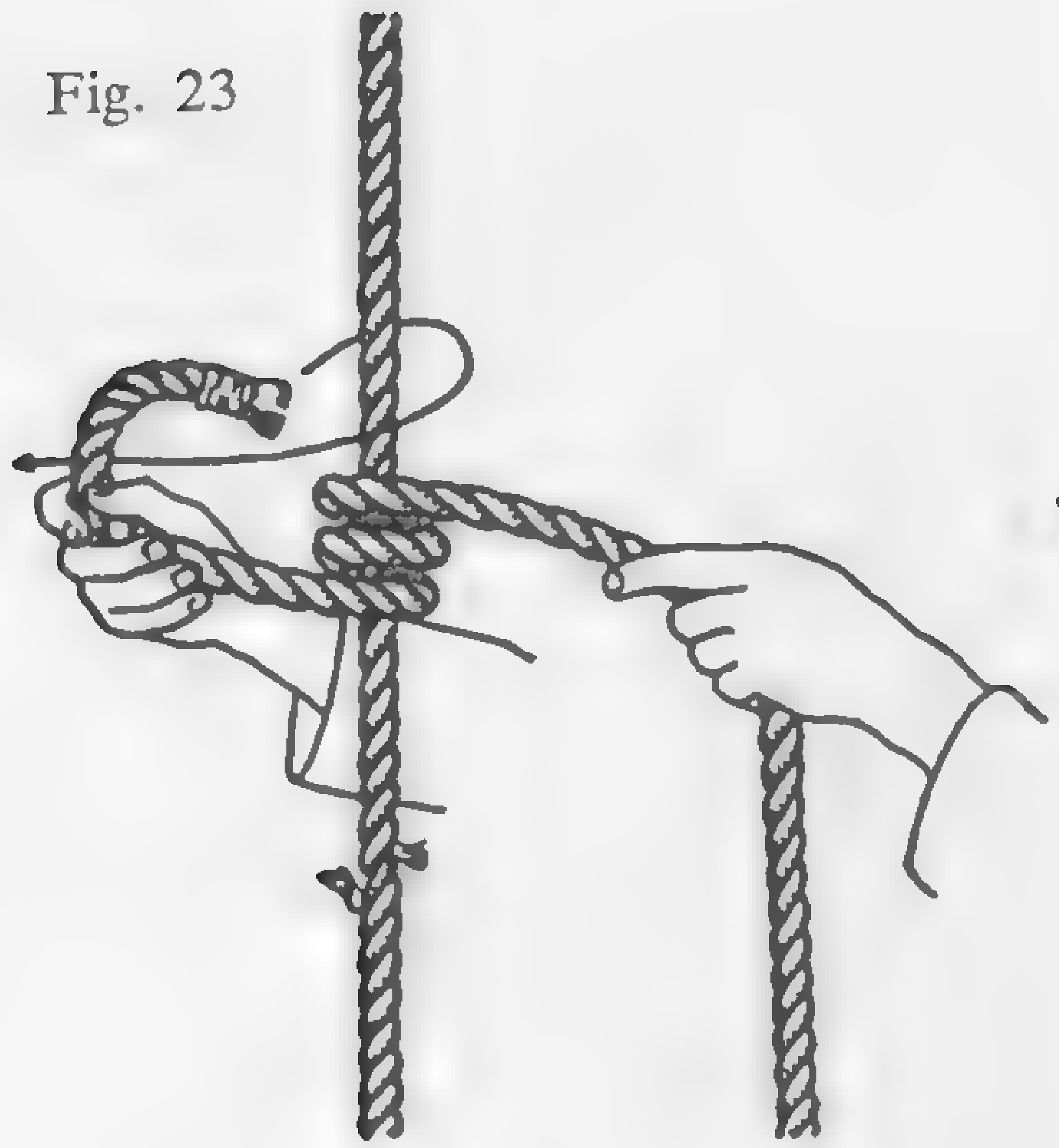


Fig. 24

### Taut-Line Hitch

Many times it is necessary to attach a rope to a second rope that is supporting a load and cannot be bent, i.e., a strand may break and it becomes necessary to attach a new rope above the break to support the load while the break is repaired.

Wrap the new rope two full turns around the taut one, progressing away from the load or in the direction of the pull as in Fig. 23. Pass the end over the wrapping and toward the load; draw it firmly, and take one or two half hitches about the taut rope between the wrapping and the load, as indicated by the arrow in Fig. 23, and as shown in Fig. 24. The hitch will not hold unless the wrapping and the half hitch are pulled up securely in the first place and are tightened as the strain is put on the new rope.

With this taut-line hitch above the break the rope may be spliced or the strand repaired with no danger of the load slipping.

## How To Make Fast

Many methods of making fast are used but the correct one is usually the easiest. One easy but effective method is illustrated here (Fig. 25–Fig. 28).

To make fast: loop the running part around the cleat's far side, away from the direction of the strain.

Then take a turn around the stem with the running part and up and over the center (additional turn would jam the line).

Add several more figure eights; or, if there is little strain, slip a half hitch over a horn of the cleat immediately.

Your line is now made fast, yet ready for prompt cast-off with no part under tension-binding loops.

This method makes it easy to cast off without having to take up the slack in the standing part, and ensures against accidents that occur when lines could not be freed quickly.

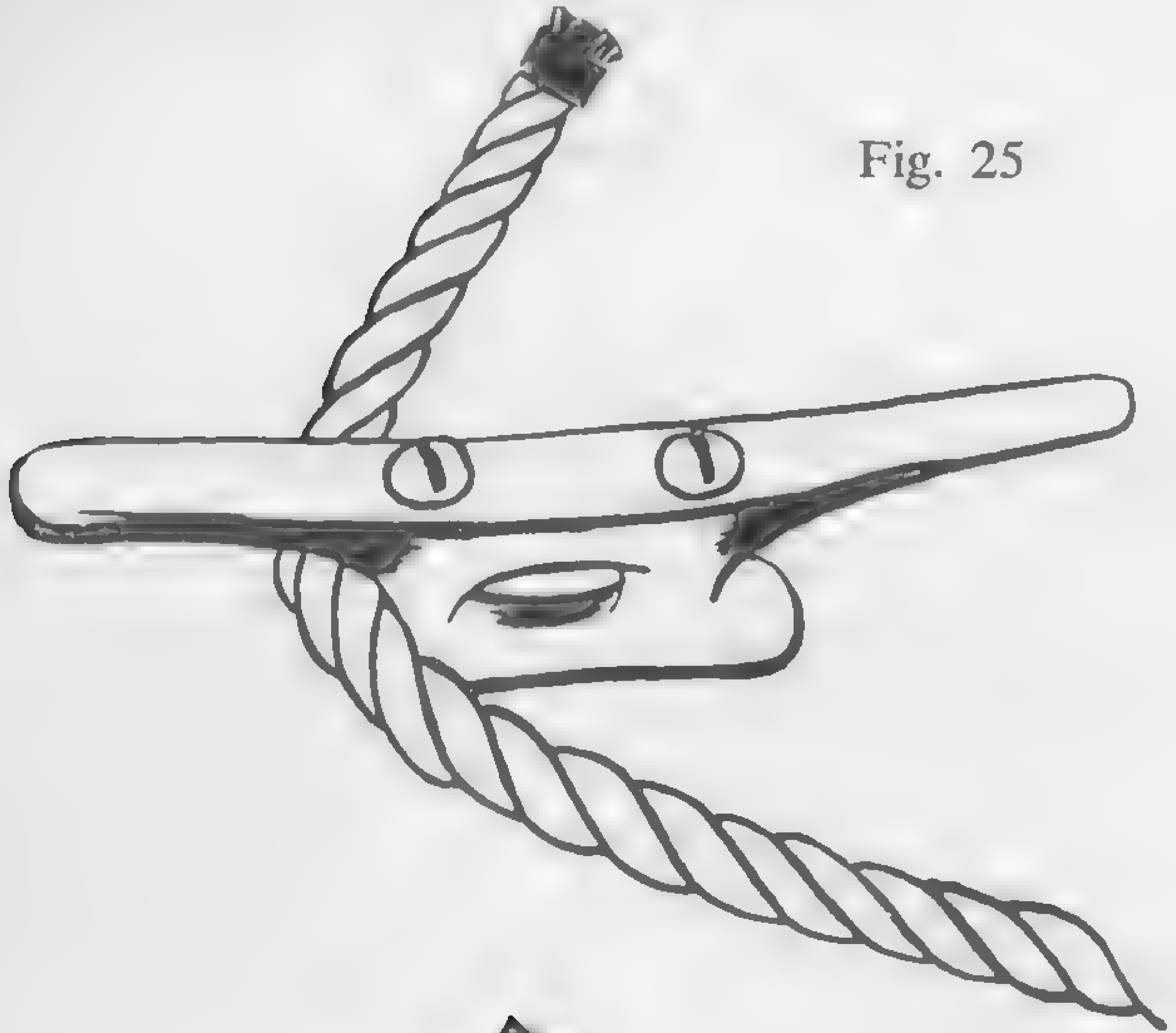


Fig. 25

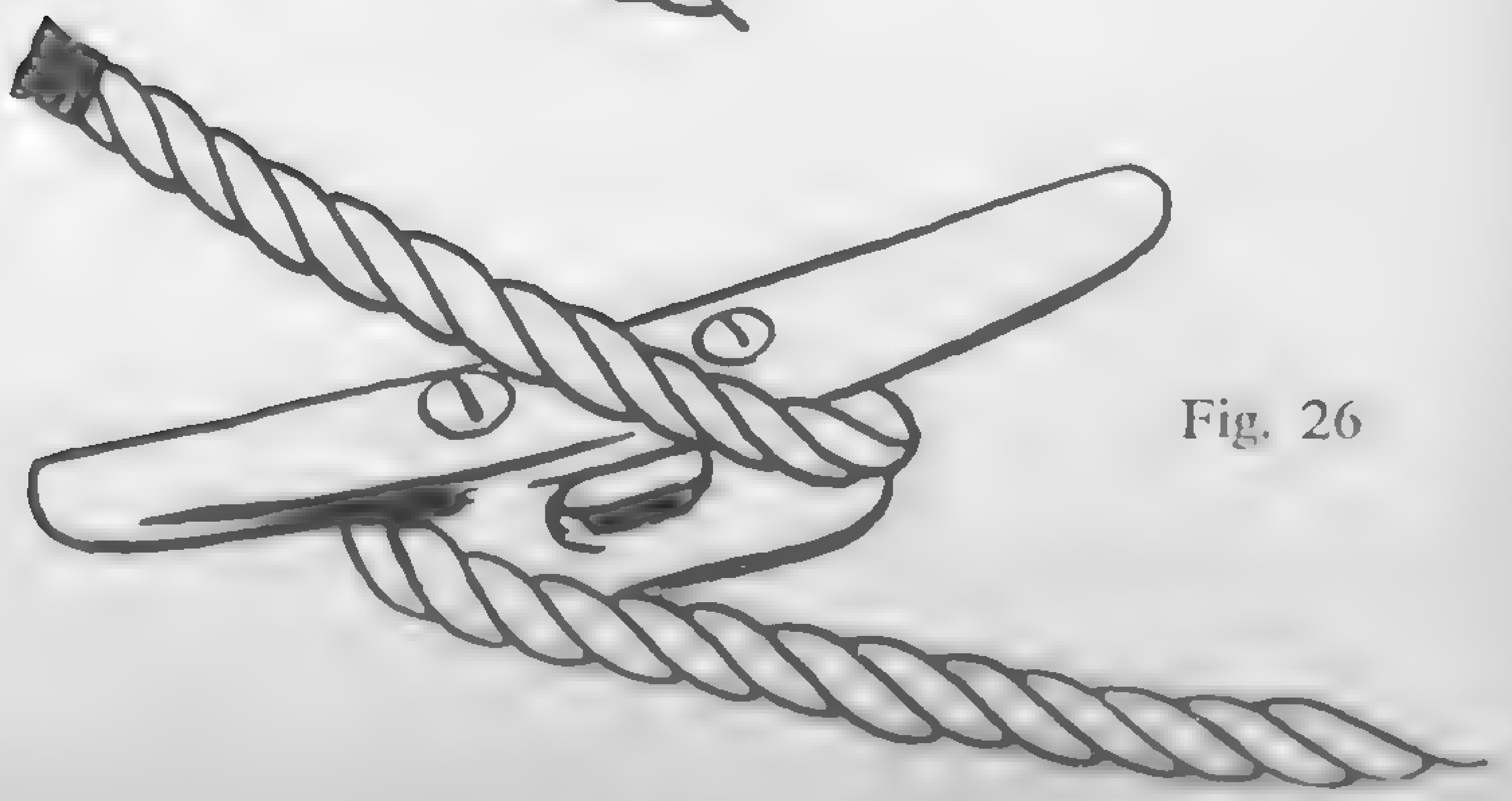


Fig. 26



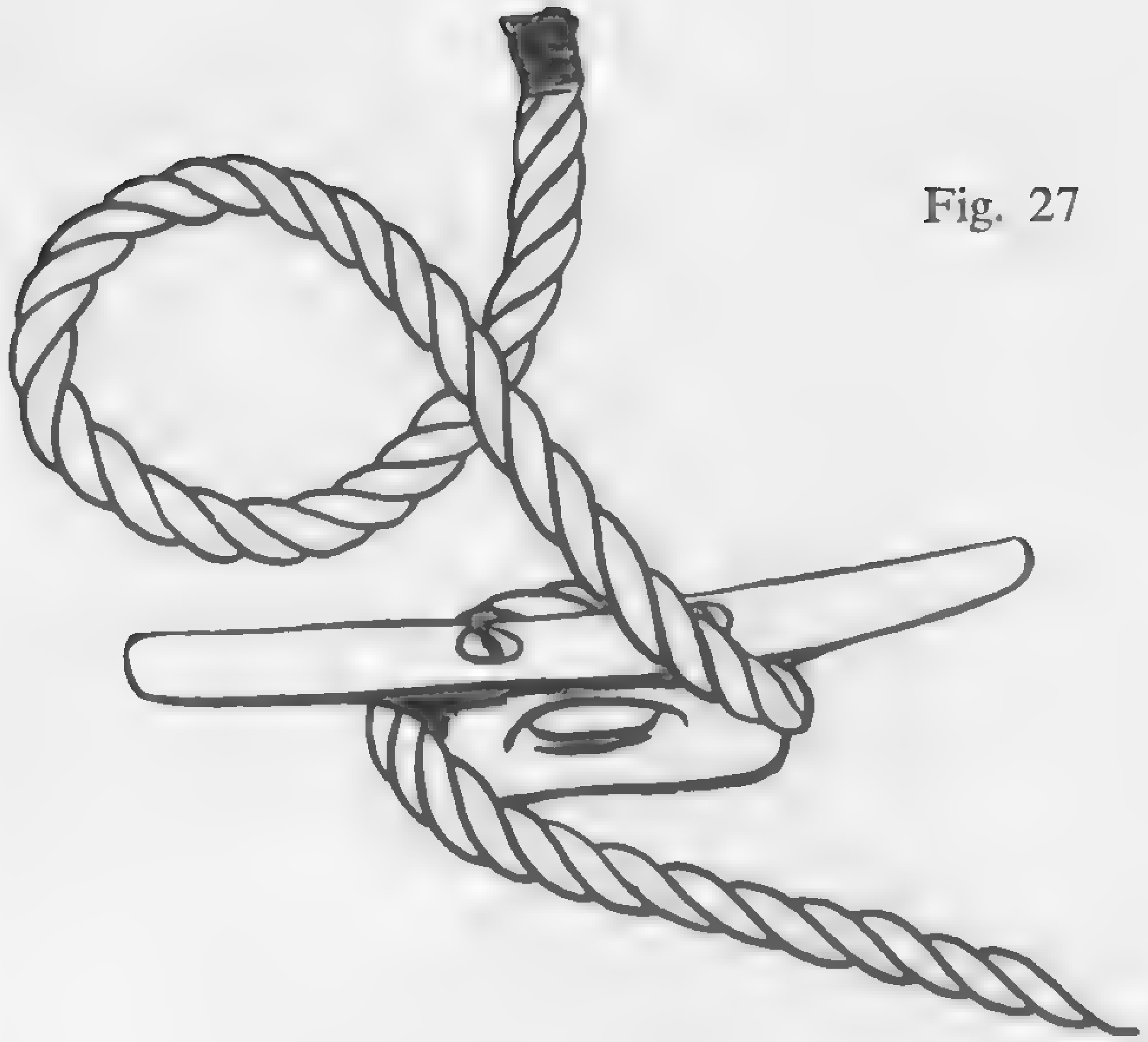


Fig. 27

Fig. 28

**Long Splice**

There are two kinds of splices, the short splice and the long. We shall deal with the long splice first, as it is the splice necessary to use when the rope is to be run through the original pulley blocks.

Unlay one strand of each rope from ten to fifteen turns. Lock the two ropes together with the single strands A and B side by side (Fig. 29). Unlay strand A from its rope one turn and follow it with strand B. Continue this operation until only a foot or less of strand B (depending on size of rope) is left out (Fig. 30).

Then untwist the two pairs of strands left at the center and lock them as shown in Fig. 31, with C between D and F, and F between C and E. Unlay toward the left strand D and follow it by laying in C. Continue until strand C is only about the size of B in the previous operation. The break in the strands is now separated and looks like Fig. 32.

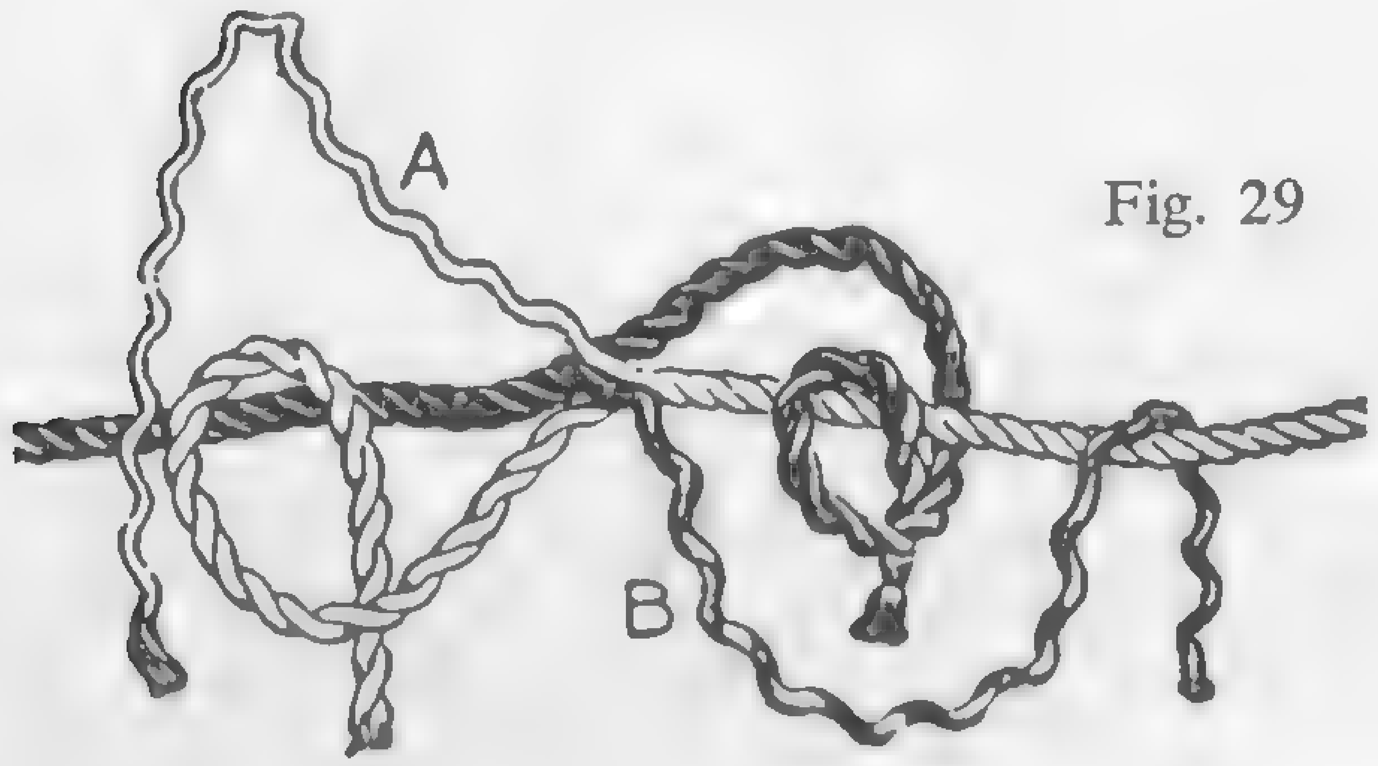



Fig. 29

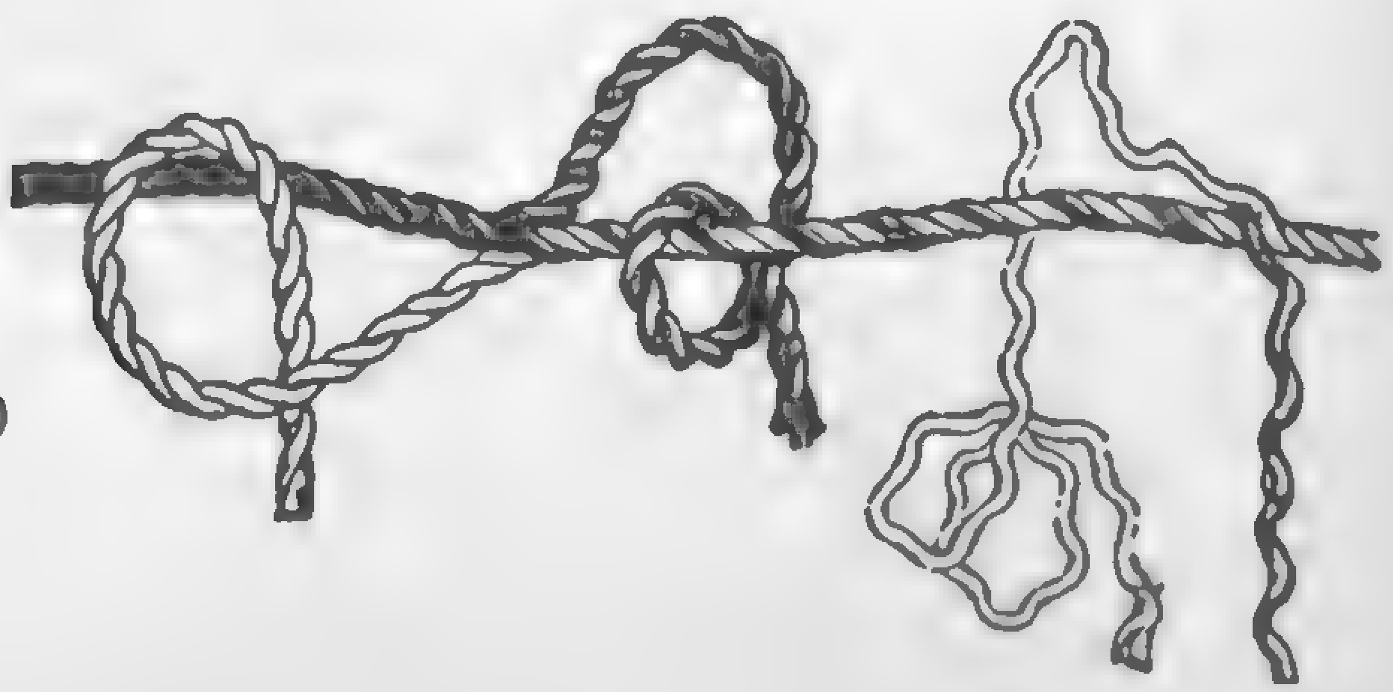


Fig. 30



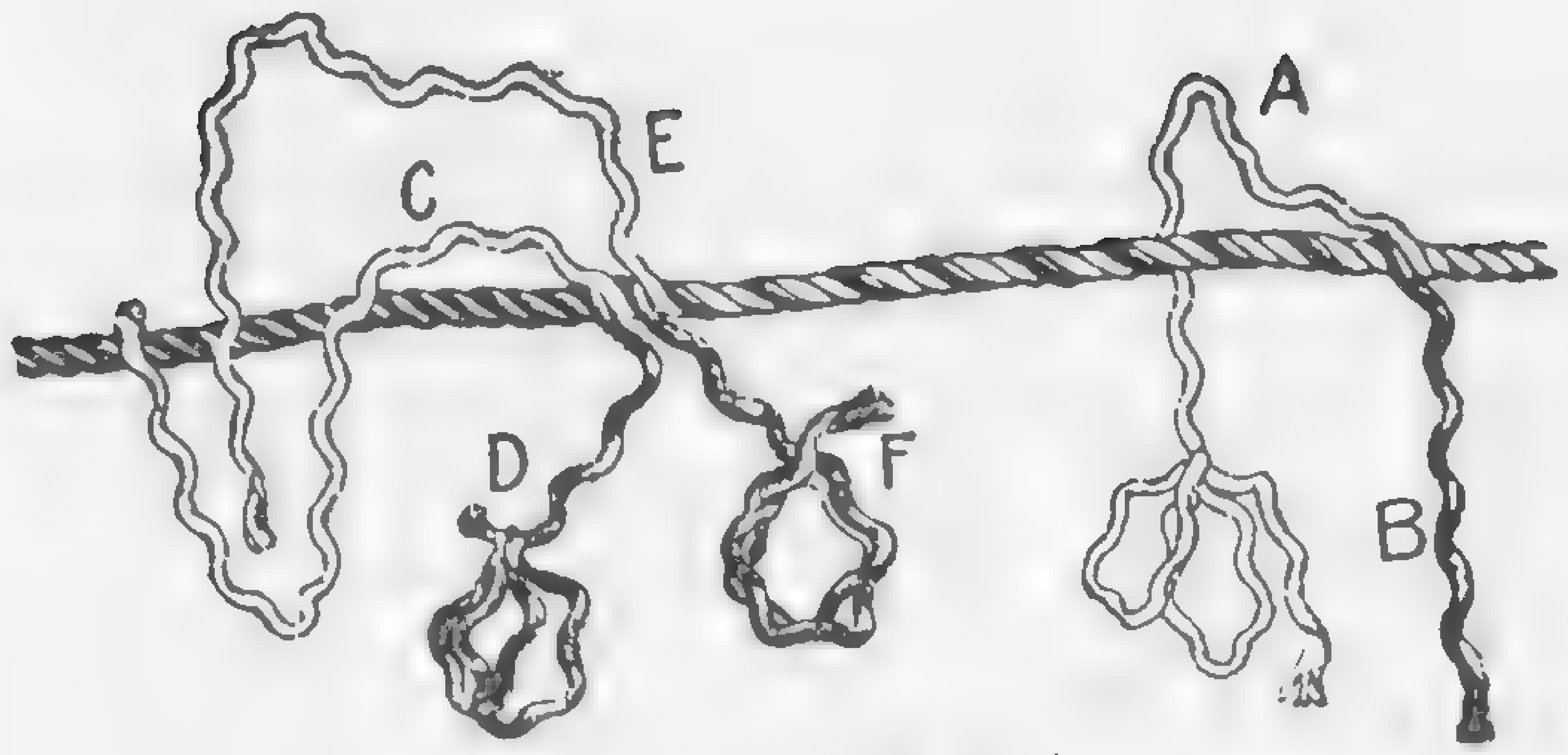



Fig. 31

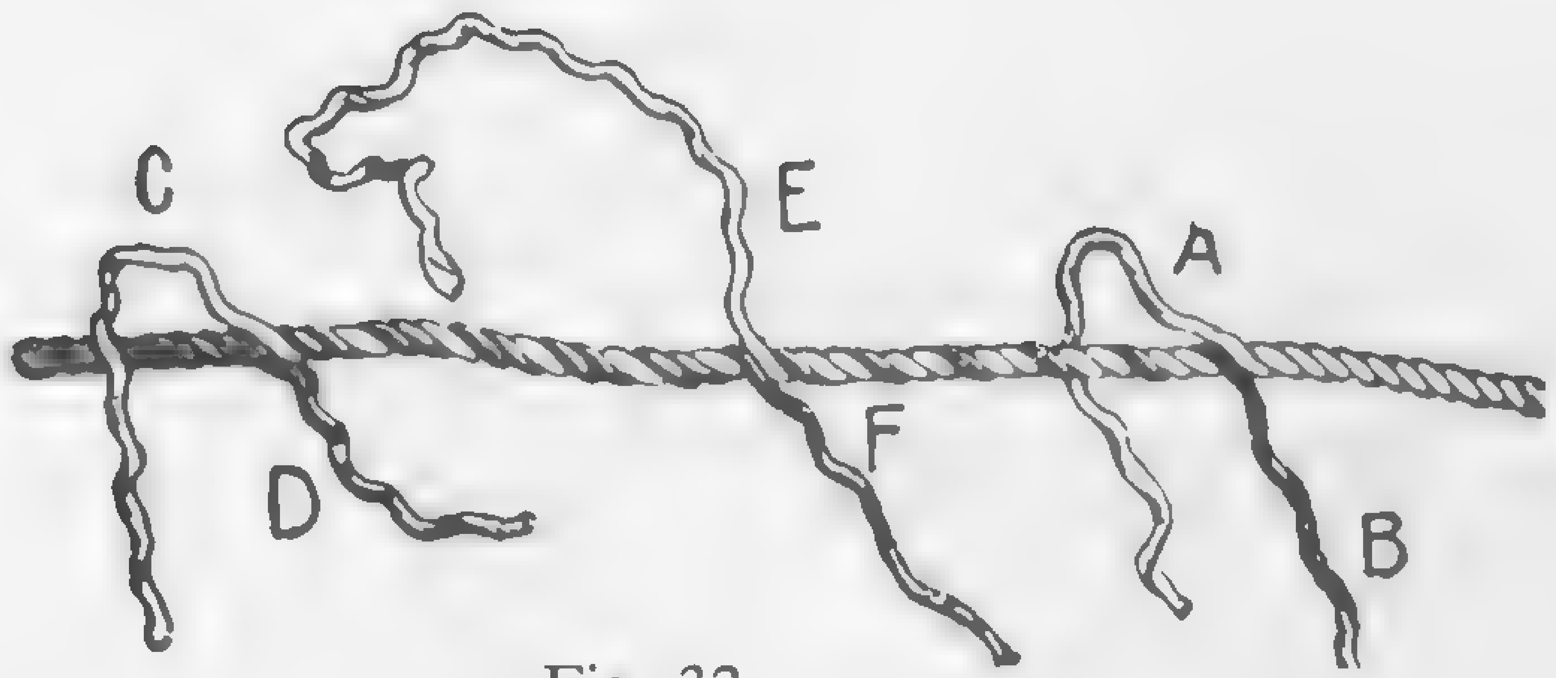



Fig. 32


Fig. 33

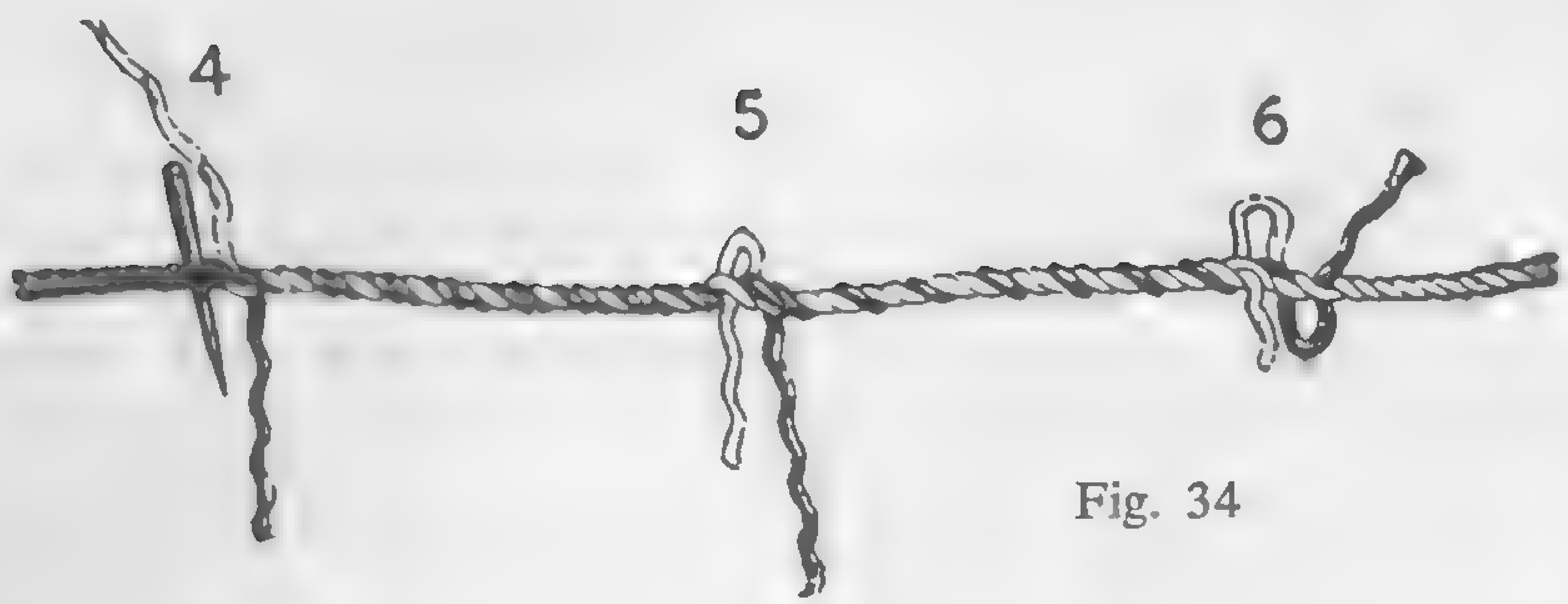



Fig. 34

In Fig. 33, each pair of strands is tied together by using a regular overhand knot. Cut all strands to the length of the shortest and arrange each pair so that the strand from the left is in front of the strand from the right. This prevents the strands from untwisting from the rope without first uncrossing (Fig. 33, 2). Tuck in each strand at 4, 5 and 6 (Fig. 34), then tuck each strand twice more, similar to 7 and 8 (Fig. 35), tapering the ends if desired, and cut the end one-half inch long as at 9 in Fig. 35. The completed splice will look like 10 (Fig. 36). Pound down each part of the splice and roll it on the floor, under the foot.

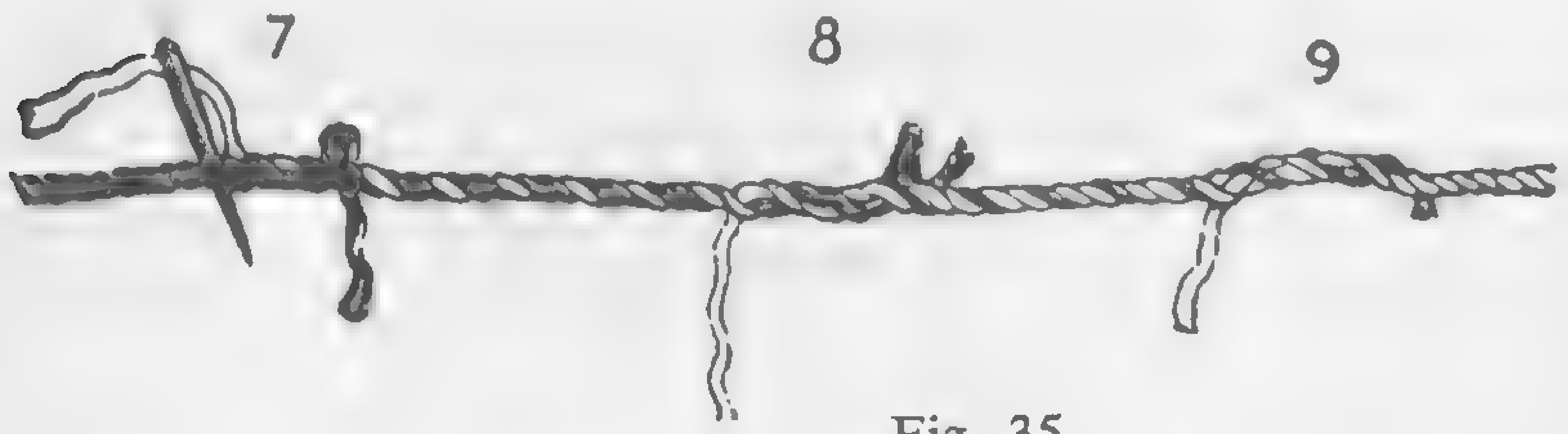



Fig. 35

Fig. 36




## Short Splice

Where it is not necessary for a rope to pass through a small pulley or where only a small amount of rope can be spared for making a splice, the short splice is very satisfactory.

Untwist the strands at one end of each rope for six or eight turns. Bring these ends tightly together as in Fig. 37 so that each strand of one part alternates with a strand of another.

With a simple overhand knot, tie each strand of one rope to the corresponding strand of the other rope as in A and B in Fig. 38. Note particularly the way in which the knot is tied. The black strand just beyond the white strand is the corresponding one for the white strand, as B corresponds to A, while D does not.

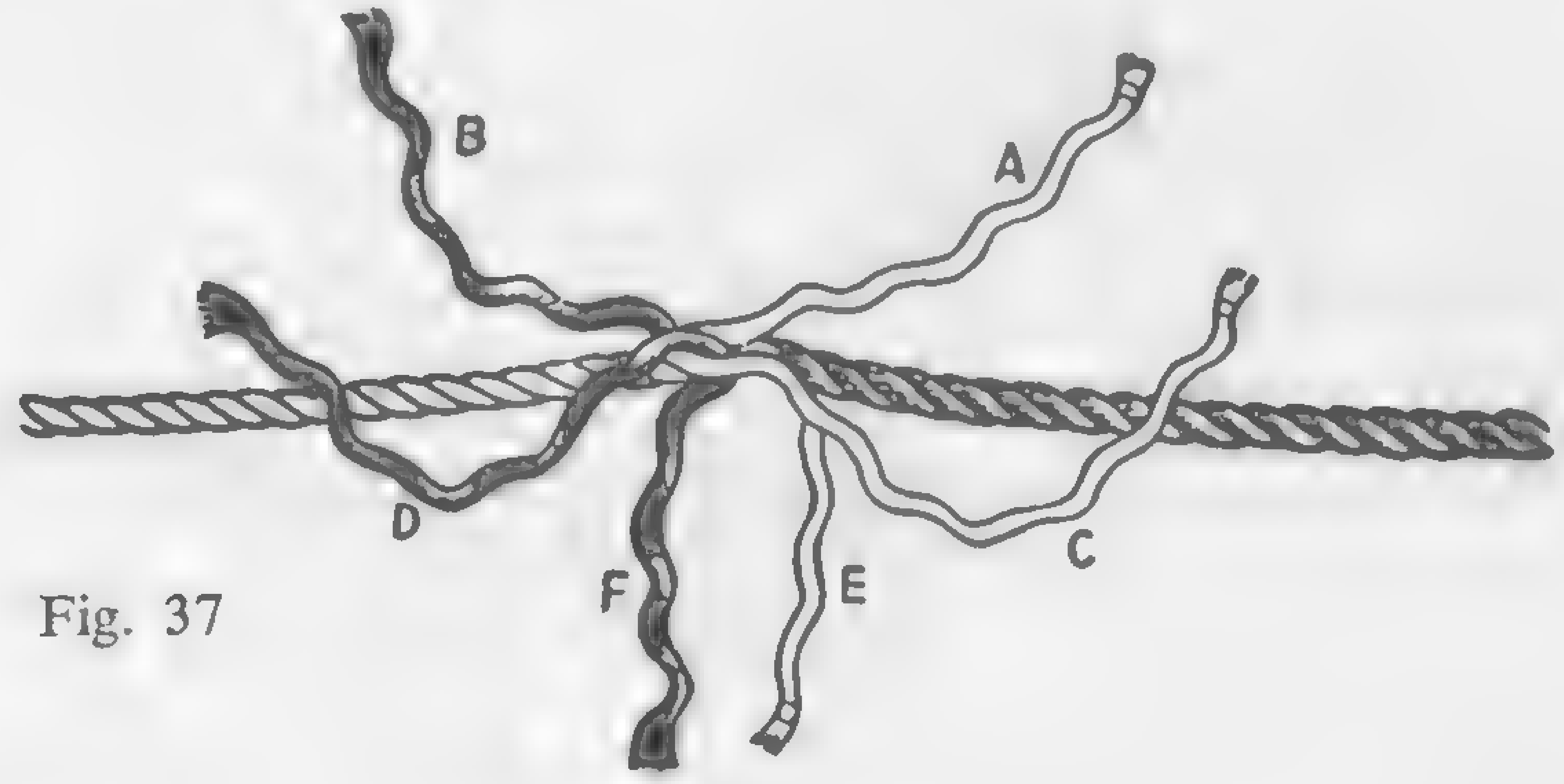



Fig. 37

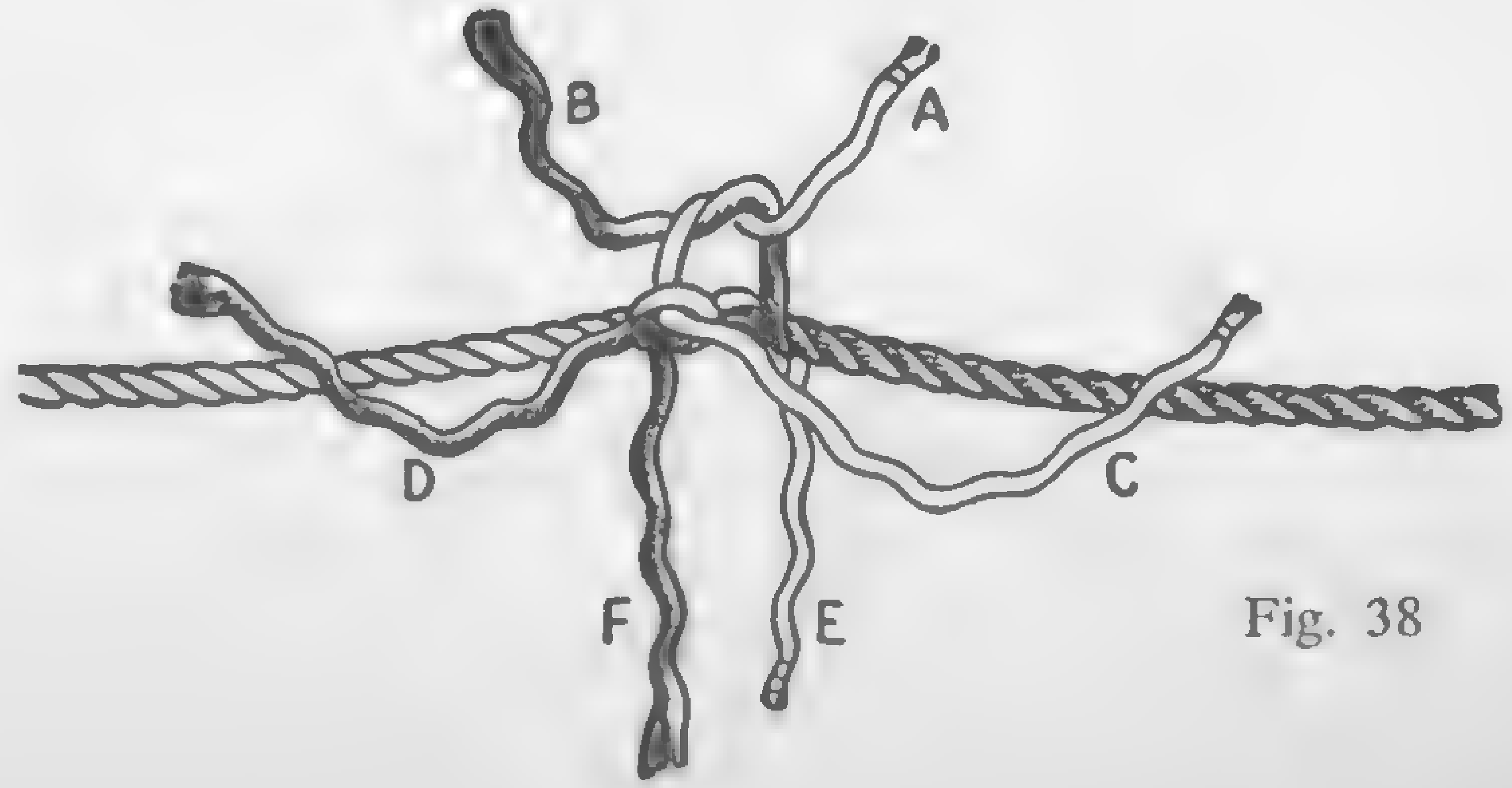



Fig. 38

The knots all being pulled down, the splice appears as in Fig. 39.

Next, begin tucking the strands from the left side by bringing a strand up over the nearest strand from the right side and down under the next. The tucking should be done at right angles to the direction of the twist in the rope. Give each of the other two strands from the left one tuck, in exactly the same manner. The splice will now appear as in Fig. 40.

Next, give each strand from the right side one tuck just as was done with the strands from the left. Give each of the strands two more tucks, always remembering to bring the strand to be tucked over the nearest one to it and under the second in a direction at right angles to the direction of the twist in the rope.

Next, divide each strand into two parts and give one part of each strand two more tucks. Cut all the ends off and roll the splice beneath your foot, or between two boards, to give a smooth appearance. The finished splice should look like Fig. 41.

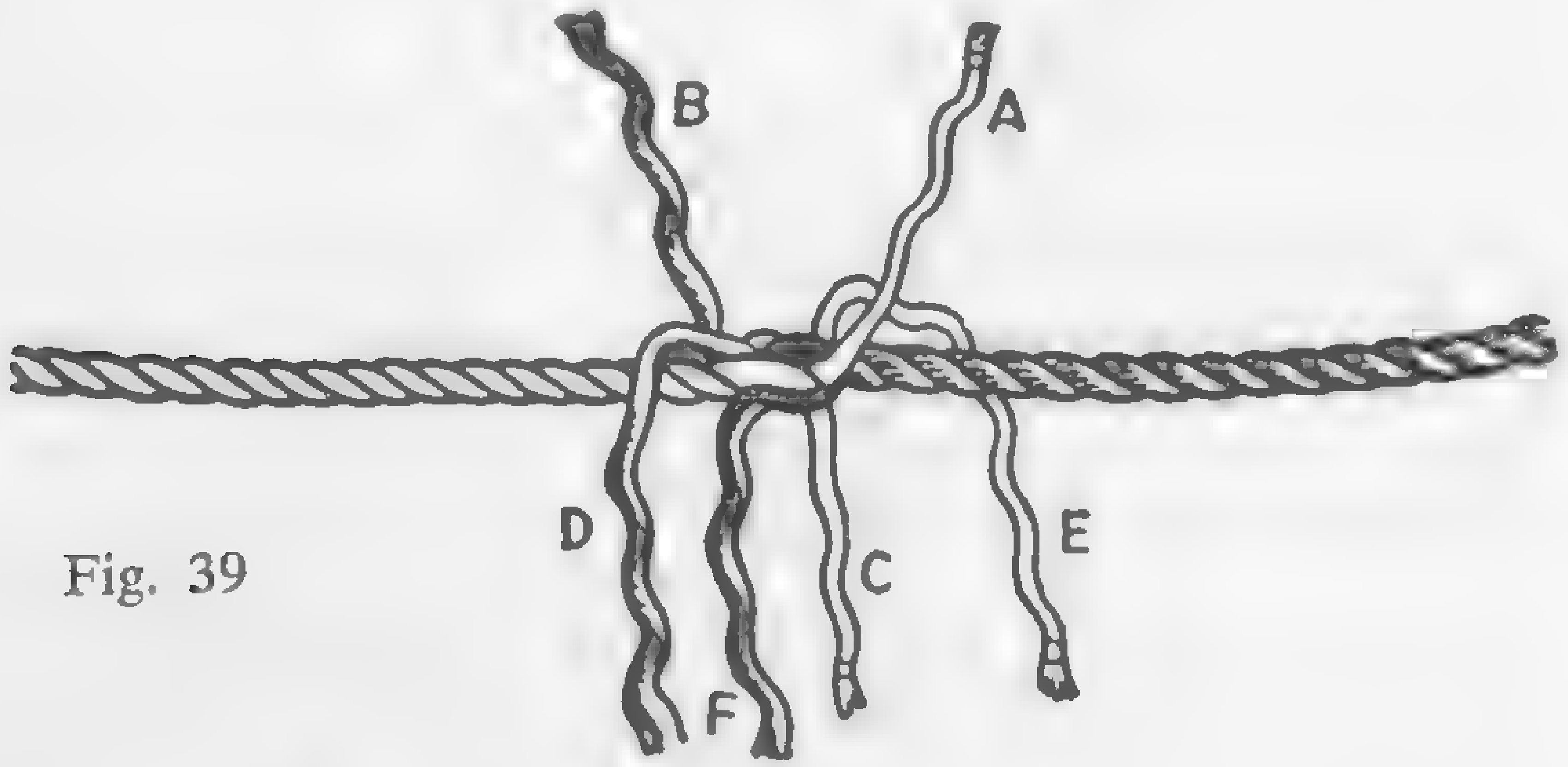



Fig. 39

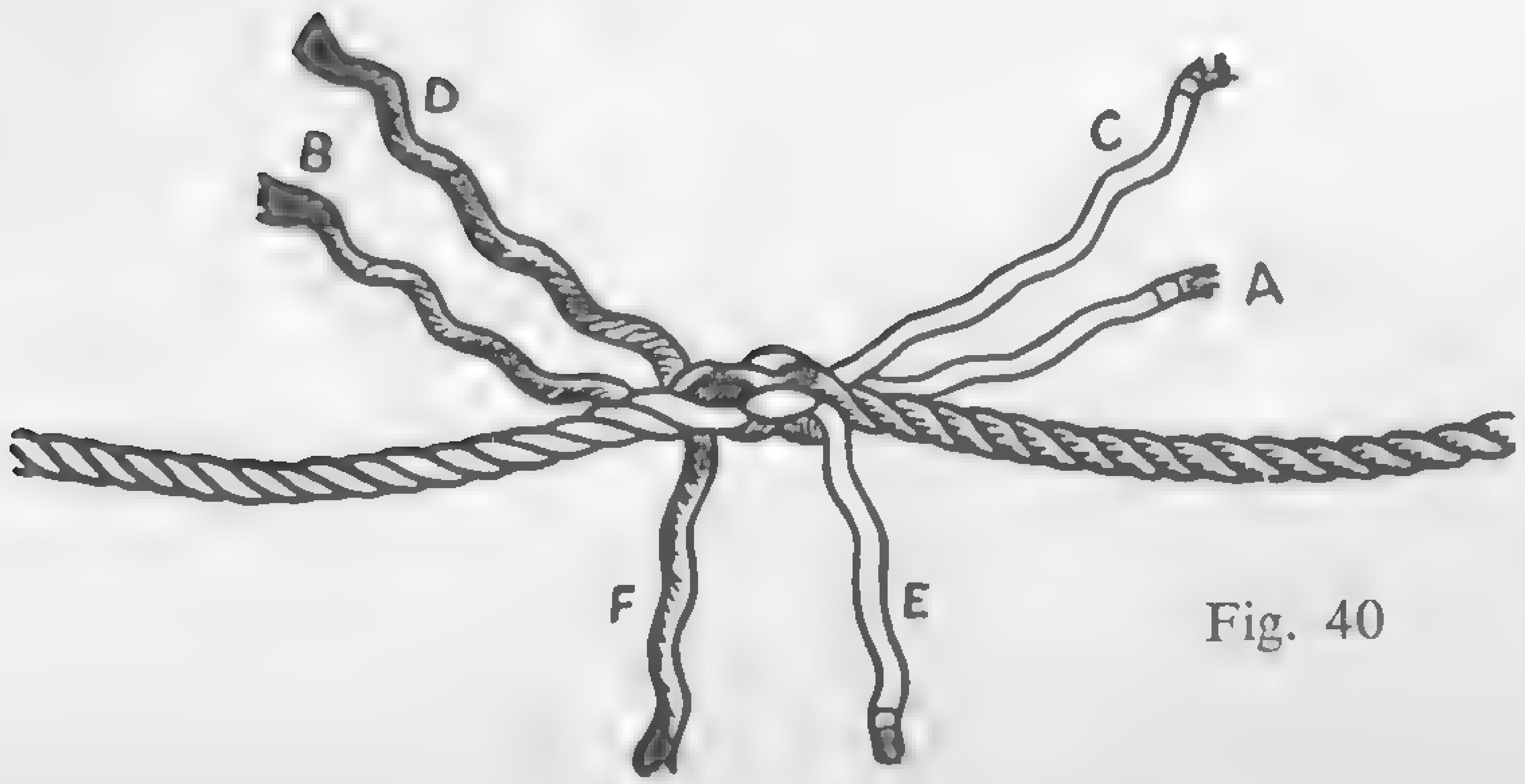
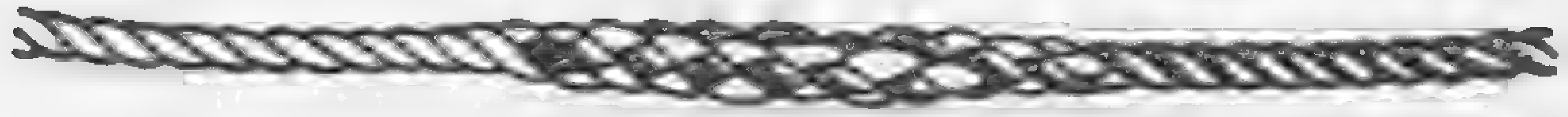



Fig. 40



Fig. 41



### Eye Splice or Side Splice

The side splice is often called the eye splice because it is used for forming an eye or loop in the end of a rope by splicing the end into the side.

Untwist the strands of the rope end four to six turns. Select as No. 1 the strand that is on top of the rope and in the middle between the other two strands. Raise a single strand on the top of the solid rope and pass strand No. 1 under this single strand diagonally to the right, as in Fig. 42.

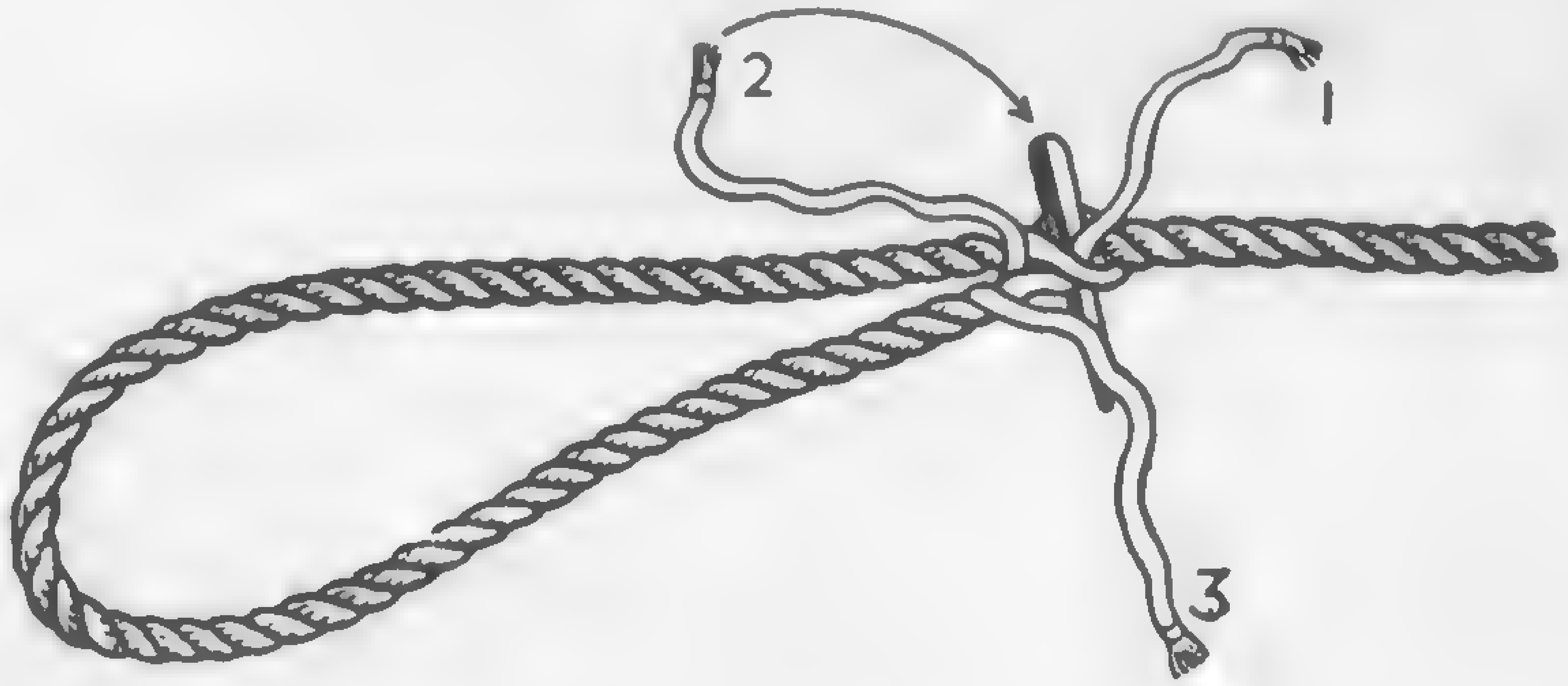



Fig. 42

Insert the marlinspike, as shown in Fig. 42, so that it forces out from the main rope a single strand and so that the end of the marlinspike comes out where strand No. 1 went in. The marlinspike must **not** enter where strand No. 1 comes out. Tuck strand No. 2 so that it passes through the rope in the same direction as the marlinspike did.

Next, insert the marlinspike as shown in Fig. 43, starting it where strand No. 1 comes out and bringing it out where strand No. 2 goes in. Turn the two ropes over, remove the marlinspike and push strand No. 3 through. Pull this strand up snugly and the others also. It will now be seen that all three strands come out of the main rope in the same place and that each is separated from the others by a strand of the main rope. Proceed to splice the ends into the solid rope as shown in Figs. 44 to 47 inclusive. This is in the same manner as given for the short splice in Figs. 40 and 41, with the exception that now we have but three strands and need to work only in one direction. The splice may be finished by dividing each strand as in the short splice and rolling the finished splice under foot.

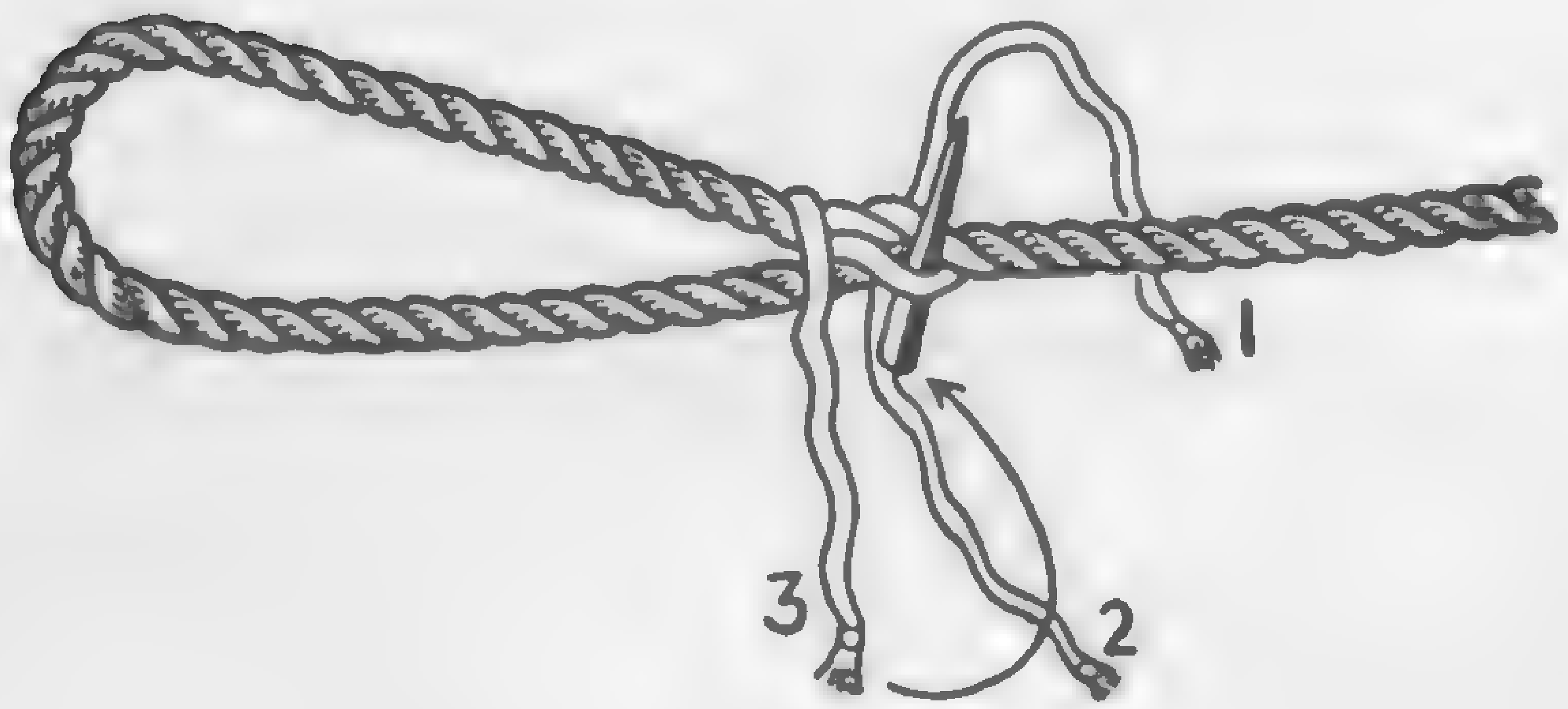



Fig. 43



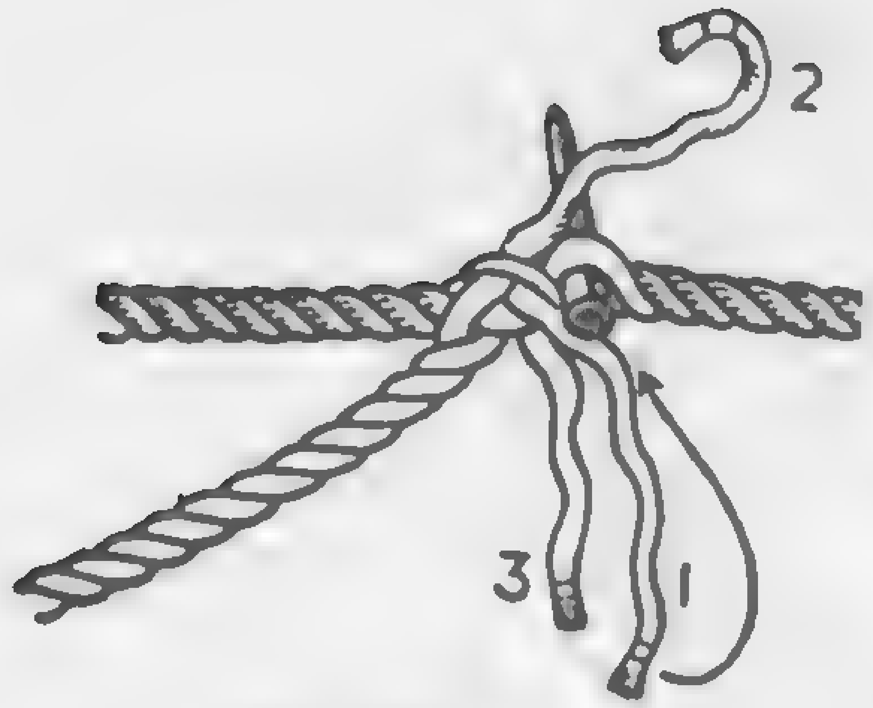



Fig. 44

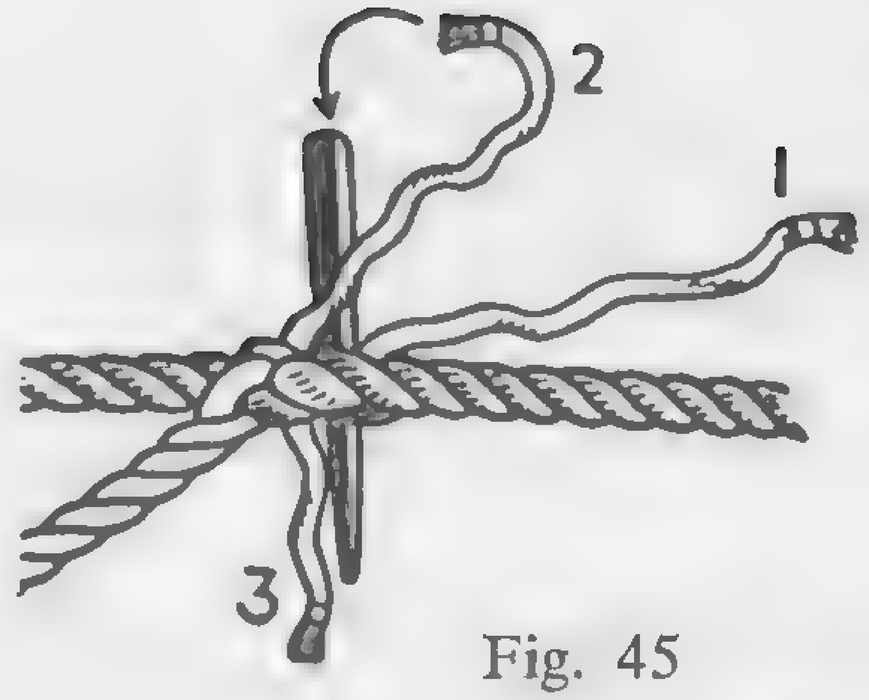



Fig. 45

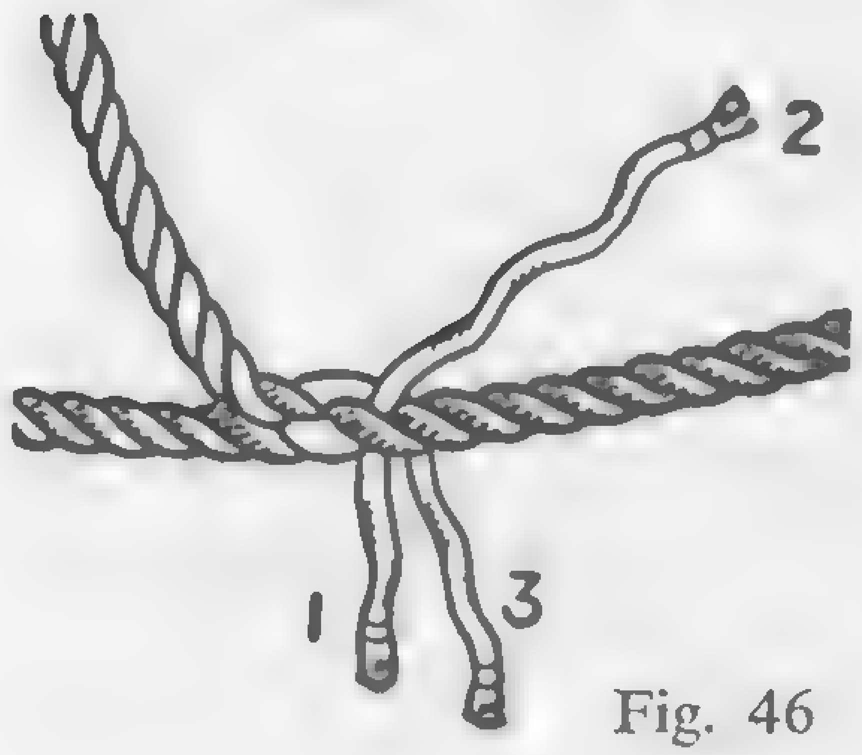



Fig. 46

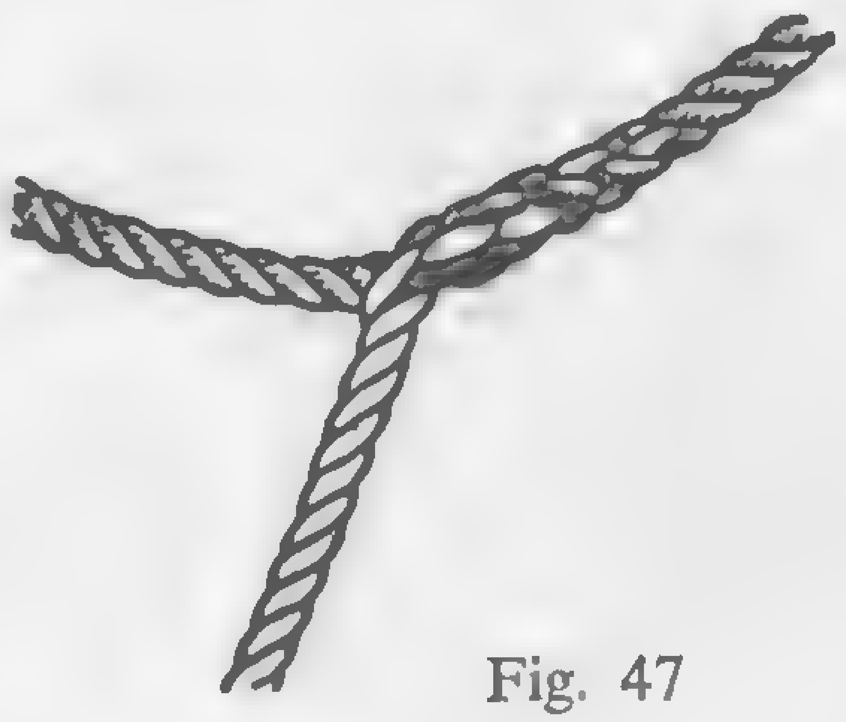


Fig. 47

**Splicing Nylon Rope**

Eye splices and short splices in nylon should be given an additional full tuck. When making a long splice in nylon, it is well to unlay one strand 6 to 10 additional turns (more than Manila) before locking the ropes together, to prevent slippage. When nylon is cut, the ends should be seized to prevent fraying.

**Splicing Ski-Tow Rope**

Use only the long splice (at least 10 feet long) which does not make the rope larger at the splice. Try to keep the tension and the twist the same in all three strands of the splice.

Winding a piece of friction tape around the end of each strand as soon as a cut is made will help to prevent the yarns of the strand from untwisting and make it easier to tuck, and finish off the splice.

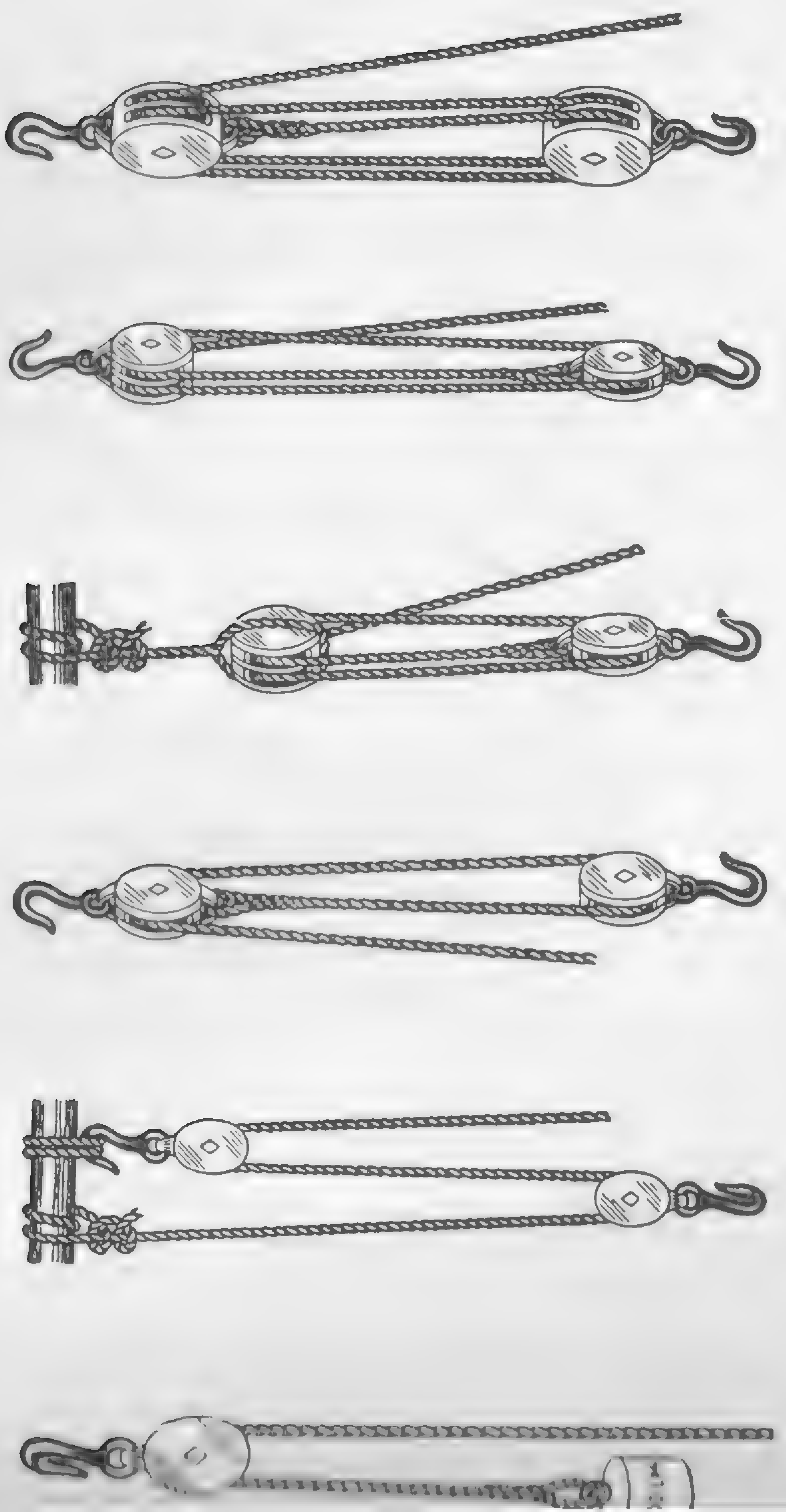


Fig. 48



**Types of Tackle:**

There are a great many types and variations of blocks and tackle. A few of the more common and most useful are illustrated in Fig. 48.

In Fig. 48 from left to right are shown:

**Single Whip** A single fixed block and fall—no increase in power. Gain only in height of lift or change in direction of pull.

**Double Whip** Two single blocks—one fixed, one moving. Double force gained.

**Gun Tackle** Two single blocks. If lower block is movable, double force is gained. If upper block is movable, triple force is gained.

**Handy Billy** A double block with a fall and a single block with a hook. Force gained, triple.

**Luff Tackle** A double hook-block and a single hook-block. Force gained three if single block is movable, four if double block is movable.

**Double Tackle** Two double sheave hook-blocks. Force gained four or five, depending upon application.

The force gained as given in all of these tackle combinations is theoretical only, as the friction of the blocks has been ignored.

### French Bowline

This bowline is a useful one-man sling. The man's weight pulls the armpit loop taut and prevents him from falling out even if he becomes unconscious. It has been employed by sailors for years on hazardous work as a man can use both hands at once without falling out.

It is formed as a regular bowline (Fig. 13) except that end D instead of going about the standing part (E) at once, is given a round turn about the bight of the gooseneck (A) and the knot is finished off as before (Fig. 49).

This leaves two loops that are loosely connected through the gooseneck. They are made so that a man can sit in one (B) while the other (C) goes under his armpits, the knot being at his chest. The weight of the man sitting in B pulls the armpit loop taut so he cannot fall out.

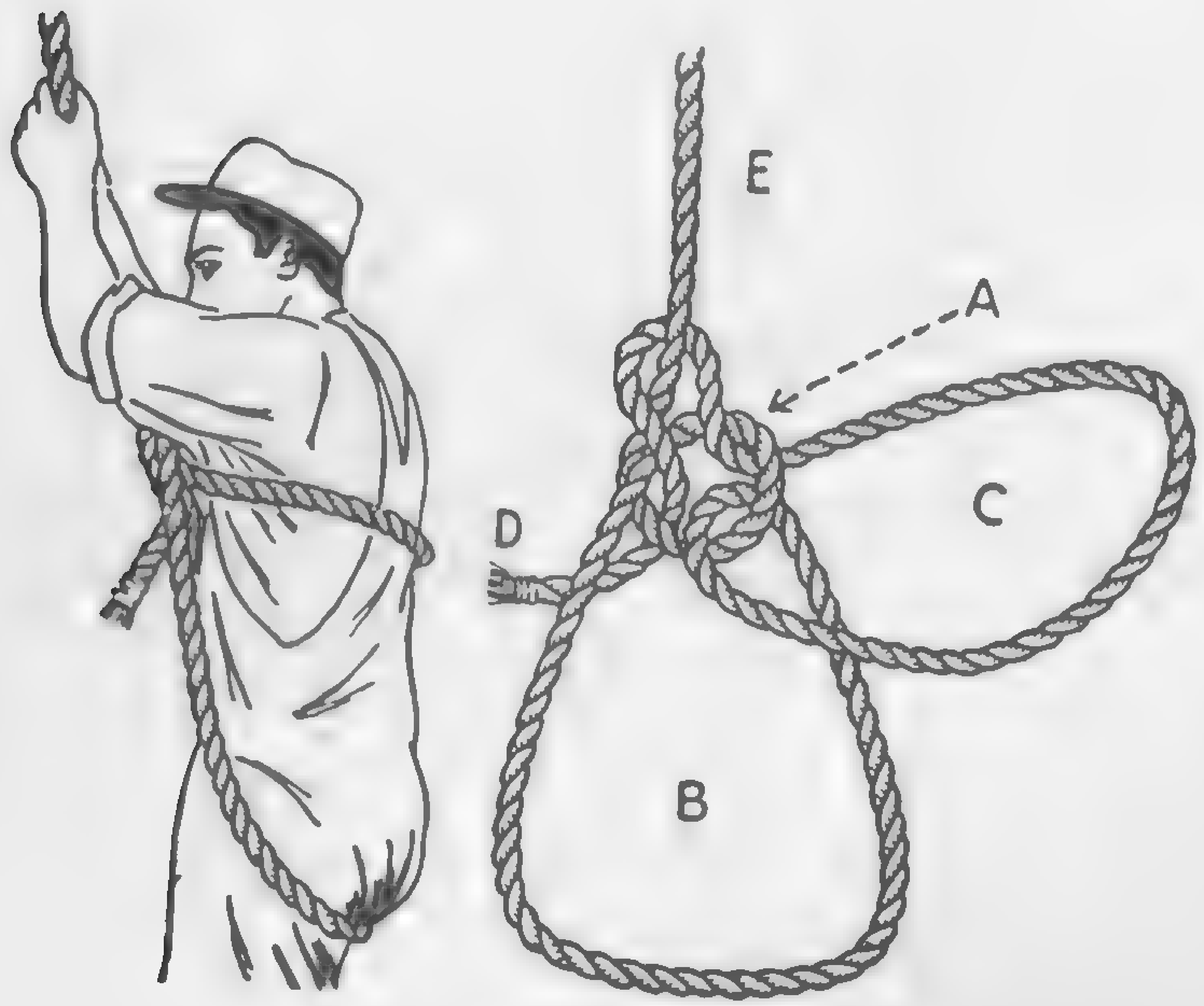



Fig. 49



## GLOSSARY

| | |
|---|---|
| Acetone | Inflammable chemical used as a solvent for paint and plastics, and as a drying agent. |
| After (adj.) | Indicates direction toward stern. |
| Ape | European term for mizzen. |
| Apron | Knee joining or bridging stem and keel. |
| Athwartship | Direction at right angles to length of boat. |
| Backstay | Wire running from mast and attaching to hull or at rear stern. |
| Backstay lever | Device for slackening or tightening running backstay(s). |
| Bail (bale) | See vail. |
| Ballast | Nonstructural weight used to gain stability or trim. |
| Barnacle | A shellfish which grows on any underwater surface not protected by poison paint. |
| Batten | Stick(s) inserted into sail along trailing edge to help sail take proper curvature. |
| Beacon | Navigation light. |
| Beam | Maximum width of boat; also athwartship members supporting deck. |
| Bearing | Direction in degrees or points of compass; support for moving or fixed mechanical device. |
| Becket | Loop or eye for attachment. |
| Beetle | Old-fashioned caulking tool for heavy work. |
| Berth | Any surface used for sleeping accommodations. |
| Bevel | To cut at an angle from perpendicular; a tool for marking and measuring angles. |
| Bilge | Hull of boat from waterline to top of structural keel. |
| Billy | Light, portable rope and pulley system which can be used anywhere. |
| Binnacle | Stand or housing for compass. |
| Bitt | Vertical post used for mooring line, usually near bow. |
| Block | Complete pulley unit. |
| Bobstay | Rod or wire holding down tip of bowsprit and running to stem near waterline. |
| Boom | Horizontal spar, with one end pivoted to mast or stay at foot of sail and adjusted by sheet at opposite end. |
| Boomkin (pronounced bum-kin) | Extension over stern of sailboat to take backstay and/or sheet. |
| Bow | Entire forward part of boat. |
| Bower | Old term for anchor carried permanently forward. |
| Bowline | Rope(s) for mooring, attached at bow; a knot forming a non-slip loop. |
| Bowsprit | Spar extending forward from bow of boat at sheer line. |
| Bowsprit shrouds | Horizontal wires supporting bowsprit against thwartship motion. |

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| Braze | Method of welding using a brass rod. |
| Breaker points | High voltage switch in distributor, which opens and closes to store and release energy from the coil to the spark plugs. |
| Breasthooks | Knees attaching stringers at bow. |
| Brightwork | Varnished wood. |
| Bulkhead | Partition, usually (but not necessarily) structural. |
| Bung | Plug through skin of boat or over fastening. |
| Butt | End-to-end joints, sometimes against a special piece of material employed just at such joints and called a butt block. |
| Bypass | Term used in connection with circulation of engine water when alternate route and valve control are available to redirect all or part of the water being circulated. |
| Cam | Eccentric rotating unit which alternately presses and withdraws from another unit moved by the cam, such as a valve. |
| Camshaft | Shaft with eccentric built-up areas for operating valves, or breaker points. |
| Carburetor | Part of gasoline engine in which fuel is metered and vaporized. |
| Carlin | Fore-and-aft structural part of underside of cabin or deck. |
| Catalyst | Chemical which promotes or controls a reaction but is otherwise nonparticipating in that reaction. |
| Catboat | Fore-and-aft rigged boat with single mast on which only one sail is carried. |
| Cat ketch<br>Cat schooner<br>Cat yawl | Two-masted boat carrying only one sail on each mast and having mast sizes and locations proportioned to ketch, schooner, or yawl. |
| Caulking | Any material used to fill seams against weather or water. |
| Cavitation | Churning of propeller in water so that blades rotate without driving water away in fore-and-aft direction. |
| Cavitation plate | Horizontal plate fitted above propeller to prevent vertical escape of water. |
| Centerboard | Board or plate lying vertically in fore-and-aft plane and pivoted so it can be raised or lowered to control lateral resistance of boat. |
| Centerboard pennant | Line for centerboard raising or lowering. |
| Centerboard pin | Pivot for centerboard. |
| Centerboard trunk or well | Watertight enclosure of centerboard. |
| Chain plate | Any strap on hull to which a rigging wire or rope attaches to support a spar. |
| Channel | Filler piece used on old-fashioned narrow boats to hold chain plates further away from hull. |
| Chart | Navigational map; also verb meaning to plot. |
| Chine | Angle between hull and bottom of "V" on flat-bottom boats. Also member to which hull and bottom attach. |



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| Chock | Jaws through which mooring line passes to prevent it from injuring boat and retain it in position. Also support for hull when out of water. |
| Clamp | Fore-and-aft structural member tying together upper parts of frames inside hull. |
| Cleat | Fitting for attaching running part of rope or wire. |
| Clevis | Notch in lever inside of which another lever hinges. Also a jaw to receive another fitting. |
| Clew | After, bottom corner of sail. |
| $CO_2$ | Carbon dioxide gas, harmless but nonlife-supporting gas used for fire fighting. |
| Cobalt | Chemical frequently used to accelerate "cure" or reaction of polyester resins. |
| Cockpit | Above-deck area of boat set at least partly below sheer line. |
| Coil | Electric device made of concentric turns of wire in one, two, or more different sizes to employ the flow of current to generate an electric field. |
| Commutator | Part of engine's electrical generator which delivers current. |
| Companionway | Main entrance into cabin. |
| Compass | Magnetic or inertial direction indicator; an instrument for drawing circles. |
| Condenser | Arrangement of electric conductors and insulators to accept a surge of electricity and deliver it slowly. |
| Consolan | Radio navigation system. |
| Cotter pin | Small retaining pin through larger pin or bolt at right angles. |
| Cradle | Framework for hauling or storing boat. |
| Crankshaft | Maindrive shaft inside engine. |
| Cringle | Eye in sail for tying out or reefing. |
| Cut-out | Automatic electric shut-off switch. |
| Cylinder | Tube in which a piston operates. |
| Davit | Structure for hoisting and retaining small boat or anchor. |
| Deadwood | Solid area of boat below and aft of garboard and stern rabbet. |
| Deionizer | Unit for making water electrically neutral, to reduce rusting and salt deposits. |
| Diesel | Oil-burning internal combustion engine using no spark for ignition. |
| Distributor | Part of engine's electrical circuit which controls order and time of fuel ignition in each cylinder. |
| Dividers | Two-legged, pivoted instrument for measuring distance. |
| Downhaul | Any line for putting tension on the luff of a sail or for pulling a sail or spar down toward the deck. |
| Draft | Amount of water a boat requires to float. |
| Drag | Boat's resistance to motion because of shape and friction. Also slipping of anchor or mooring. |

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| Drift | Amount or direction boat moves from influences not of its own choosing, such as tide drift. |
| Drift rods (also "drift") | Rods driven into wood or timbers at varying angles, thereby holding because of their geometrical pattern. |
| Drogue | Sea-anchor, a conical fabric device dragged in the water to reduce drift. |
| Elbow | Plumbing fitting for attaching pipes at an angle to one another. |
| Electrolysis | Condition of decay in a metal caused by electricity from any source including presence of another metal. |
| Engine bed | Vertical members supporting dead-weight, thrust and torque of engine. |
| Epoxy | A polymerizing resin of extreme strength used as an adhesive and as a plastic for molding or laminating. |
| Fiberglass | Literally glass fibers. May be powdered, chopped, matted or woven into fabrics. |
| Figurehead | Ornament figure at bow of boat, beneath bowsprit. |
| Fillet | Built-up curve to eliminate sharp angles. |
| Flam | Cross-sectional curvature of hull above water, always convex on outside of topsides. |
| Flare | Cross-sectional curvature of hull above water, always concave on outside of topsides; also a signal torch. |
| Floor (also floor timber) | Thwartship structural member(s) seated on keel. Purpose is to transfer load on frame bottoms to the keel and to help secure the garboard plank. |
| Flotation tank or compartment | Volume of permanently entrapped air to provide extra buoyancy in event of boat being injured. |
| Flush | Lying in the same plane as the adjacent surface. |
| Flywheel | Wheel-shaped weight on engine shaft, provides inertia to smooth out engine vibrations and provides gear teeth for starter to engage. |
| Foot | The bottom edge of a sail; to sail fast. |
| Forecastle (pronounced fo'c's'l) | Old term for forward cabin. |
| Foredeck | Deck at bow of boat. |
| Forepeak | Below-deck area right at bow of boat. |
| Foresail | Sail setting on forward mast of schooner (American). |
| Forestay | Stay running from lowest forward position on mast to forward deck. |
| Formica | Quality surfacing plastic in sheet form. |
| Forward guy | Line holding outboard end of any boom toward the bow. |
| Frame | Vertical member(s) of skeleton, always paired port and starboard, running from keel or floor timbers to sheer for purpose of shaping and holding skin of hull. Sometimes called "rib." |
| Freon | Inert gas, compressed to liquid. Used to provide pressure in spray cans. |



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| Gaff | Spar along head of quadrilateral sail; a large barbless hook on rigid handle, used for lifting fish. |
| Galvanize | To coat with zinc by electrolytic or molten-dip process. |
| Gammon iron | Strap over bowsprit, retaining it to stem. |
| Garboard | Bottommost plank or area of hull above keel. |
| Genoa jib or genny | A jib which extends aft beyond the mainmast. |
| Gibson girl | Portable radio for transmitting distress signals. |
| Gimbal (pronounced jim-bal) | A pivoted support for an object which allows gravity or inertia to keep that object level despite motion of the boat. |
| Gland | Watertight fitting through which wire, shaft, pipe or rod enters hull. |
| Gollwobbler | Over-sized sail on schooner, going forward from top of mainmast. Also called maintopmast queen staysail. |
| Gooseneck | Pivoting joint where boom and mast meet. |
| Grommet | Metal or stitched eyelet through fabric or sail. |
| Gudgeon | Eyebolt, eyeplate, or eyestrap into which fit hinge pins (generally on rudder). |
| Gunbolt | Bolt with two heads. The rod is designed to screw together halfway between the heads, the rod being cut with a female thread on one half, a male thread on the other, like a machine thread in a tube to accept an ordinary machine screw. |
| Gusset | Knee or bridge reinforcing two members attached to one another by end-to-end joint. |
| Guy | A line or rope used to oppose a sheet; the fore-and-aft leads on a spinnaker boom. |
| Gybe (also jibe) | Movement of a boat bringing wind from one side to the other over the stern of the boat. |
| Gyro compass | Direction indicator not dependent on the earth's magnetic field. Works on inertial stability. |
| Halliard (halyard, haulyard, etc., ad infinitum) | Any line used for raising a sail, flag or spar in vertical direction. |
| Hanger bolt | A two-threaded bolt, one end of which is cut with wood-screw threads and the other end of which has machine-screw threads which accept a machine nut. |
| Hatch | Any opening into a storage or living compartment which is used for access. |
| Helm | That unit of steering equipment actually handled by person steering; the wheel; the tiller. |
| Highfield lever | A lever used to take up slack quickly in a wire such as a backstay. |
| Hoist | To raise; the vertical distance the head of a sail extends, measured along its luff. |
| Hounds | Area of a mast at which gaff rides. |
| Hull | Entire body of boat from sheer to keel to sheer; also an old verb for riding out a storm without use of sail(s). |

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|---|---|
| Injector | Nozzle which delivers spray of liquid or air, particularly fuel nozzle into cylinders of Diesel engine. |
| Inlet | Opening of air, water, or fuel system where the substance first enters system. |
| Ionize | To make electrically charged in a solution. |
| Jaws | The yoke of a gaff or boom which fits around the mast; the yoke of a turnbuckle. |
| Jib | Sail on foremost, or highest, stay of foremost mast. |
| Jibboom | Spar to which foot or clew of jib is attached; spar parallel to and in connection with bowsprit, used to extend bowsprit's effective length. Carried jibstay or jib set without any stay (antiquated usage). |
| Jigger | Slang term for mizzen, the aftermost sail on a yawl or ketch. |
| Joint | To match several cuts of wood exactly — to finish a surface perfectly. |
| Jumper | Wire stay(s) passing over a short strut and having both ends attached to the same spar. |
| Jumper strut | See jumper. |
| Kedge | "Yachtsman's" anchor, traditional boating anchor; to pull boat by lowering anchor ahead and hauling boat up to it. |
| Keel | Fore-and-aft hull skeleton member to which floors, frames, stem and sternpost are attached. |
| Keel cooler | Heat exchange system of pipes inside or along keel to cool fresh water for engine. |
| Keelson (pronounced Kel-son) | "False" keel attached over floor timbers above true keel. |
| Kenyon | Term used for speed indicator manufactured by Kenyon, a firm in Huntington Station, New York. |
| Ketch | Fore-and-aft rigged boat with mainmast forward and mizzenmast (smaller) aft but forward of intersection of rudderpost and waterline. |
| King plank | Center plank of deck, notched to receive ends of curving deck planks. |
| Kite(s) | Modern collective term for "light" sails. |
| Knee | Bridge across the angle formed by two adjacent surfaces. |
| Knightheads | Structural members on older boats running parallel to frames at forward inboard sides of planking, extending through the deck at least as high as the scupper rail, often perforated to carry anchor tow lines. |
| Lag screw | A wood-screw thread on a rod which has a head designed for turning with a wrench. |
| Larboard | Old term for left side of boat. |
| Launch | Small open boat, such as yacht-club tender or inboard fishing boat; to put a boat into the water. |
| Leach | To carry off a chemical by dissolving it and washing it away. |
| Lee | Side of boat opposite to side from which wind is coming. |



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| Leeboard | One of a pair of side-by-side drop keels as used on shoal-draft Dutch boats. |
| Leech | Trailing edge of sail. |
| Leeward (pronounced loo-ard) | Toward lee. |
| Lifeline | Rope or wire fence around boat; short portable rope for crew member's individual safeguard. |
| Life preserver | Any buoyant belt, ring or jacket worn to keep a swimmer afloat. |
| Life raft | Unsinkable raft or boat for personnel emergency use. |
| Light board | Board used to support and shield running light(s). |
| Line | Any rope or electrical wire. |
| Lines | Designer's general-shape drawings of boat. |
| Log | Book in which navigational and operation data are written as in diary form; instrument for recording speed and/or distance; construction holding counterboard trunk to keel; to make good a given distance or speed. |
| Logged | To become impregnated with water or other liquid. |
| Lubberline | Reference point or line parallel to or perpendicular to keel, against which degrees on compass card are read. |
| Luff | Leading edge of a sail; shaking of sail; to head boat, bow into wind, in such a way that some wind hits lee side of sail, making it shake; trimming sail so only part of it effectively deflects wind, balance of wind passing on lee side. |
| Magneto | Self-contained high-voltage generator. |
| Manifold | Multipassage duct to engine cylinder valves; carries fuel, air and exhaust. |
| Mast | Vertical, fixed spar. |
| Mastcoat | Watertight fabric shield around mast near hole where mast enters boat. |
| Masthead | Top of mast. |
| Maststep | Socket or support for bottom of mast. |
| Mizzen | Aftermast and smallest mast of yawl, ketch or schooner having more than two masts. |
| Nylon | Dupont's extruded monofilament fiber, high-strength, non-deteriorating, used for rope, fabric, bearings. |
| Orlop | Old term for after-storage locker. |
| Outhaul | Any line for pulling a sail or piece of equipment out on a spar. Especially a line for putting tension on the foot of any sail or on the peak of a gaff-headed sail. |
| Outrigger | Long pole or lightweight spar for holding fishing lines or nets clear of boat; structure for holding pontoon away from hull of sailing canoe. |
| Palm | Leather and metal handstrap containing heavy-duty thimble for canvas and rope sewing. |
| Parrels | Rollers on lashings about mast or boom, which allow lashings to be raised or lowered without jamming. |

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|---|---|
| Partners | Wedges or fillers fitting around mast between mast and edges of mast-hole through deck. |
| Peak | Upper outboard end of a gaff-headed sail; outboard end of a gaff. |
| Pinky | Old-fashioned schooner double-ended, with high false stern. |
| Pirogue | Shallow boat used in swamp-water areas of South. Term has Louisiana-French origin in America. |
| Pitch | Angle of attack—the angle of the propeller blades is referred to as their pitch; a thermoplastic natural resin, often used to fill seams a generation ago. |
| Point | A major division of the compass, 11-1/4 degrees of arc; the ability of a boat to go to windward. |
| Porpoise | Boats which leap partly clear of water when driven fast are said to "porpoise." |
| Proa | Double-ended sailing canoe with fixed outrigger and steered by paddle. Instead of boat turning around when it sails back on opposite course, helmsman simply moves to other end, sail swings right around spar, outrigger remains to windward and boat sails away. |
| Propeller | Any wheel, disc or blade-shaped mechanism used for displacing air or water to move the vehicle to which the propeller is attached. |
| Putty | Flexible compound used to fill small holes and seams. |
| Quadrant | Literally 90 degrees of arc; also a quarter-circle of metal fitted to rudder stock inside boat to carry steering cables or gear. |
| Rabbet | Area cut into surface of a material to allow seating of more material. Example: The keel is rabbetted to receive the garboard plank. |
| Reamer | Cutting tool for smoothing and enlarging holes. |
| Reeve | To pass a wire, chain, or rope through a hole or pulley. |
| Rigging | Any piece of equipment related to spars or sails. |
| Rode (also rhode) | Chain or line from boat to anchor mooring, when boat is afloat and not at dock. |
| Router | Power tool for shaping edges and channeling surfaces of materials. |
| Rudder | Movable blade for deflecting water, reaction to which turns the boat. |
| Scarf | Long, tapered joint between two pieces of material. |
| Scupper | Drainhole; may be through rail, through hull, or through cabin or cockpit sole. |
| Sheer (also sheer strake) | Fore-and-aft horizontal curve of hull; also topmost plank of hull topside below deck. |
| Shelf | A fore-and-aft internal structural member riding parallel to the deck along the edge where underside of deck and hull intersect. |
| Shim | Thin metal, plastic or wooden pieces used to align engine on its bed, to wedge a member of the boat into position, or to fill a gap. |



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| Shoe | Protective or supporting member under the keel, centerboard, or rudder, such as the worm shoe, to prevent worm attacks. |
| Shore | To support a boat while it is on land. |
| Shoring | The pieces or assembly of pieces which support the boat when it is on land. |
| Shroud | Any wire supporting a spar from a thwartship direction. |
| Sole | "Floorboards" of boat. |
| Spreaders | Compression struts from mast(s) used to increase effective support from rigging by holding rigging wires further away from mast then they would otherwise be. |
| Springline | A type of mooring line. If it originates from the midship part of the boat, it attaches to shore near one end of the boat. If it comes from the bow or stern of the boat, it attaches to the shore near the opposite end of the boat. |
| Stanchion | Post supporting liferail. |
| Stay | Any wire supporting a spar from a fore-or-aft direction. |
| Steam-bent | Material (wood or plastic) which has been softened by a steam bath, and bent while soft. When the material regains its normal firmness it tends to remain in its new position, and, in the case of wood, steaming also kills many of the wood-attacking parasites. |
| Strapping | Metal or fiberglass-reinforced straps inside or outside hull or deck and acting as members under tension. |
| Stringer | Any fore-and-aft continuous member running inside and attaching to the frames, for the purpose of stiffening the hull. |
| Strut | Fore-and-aft spreader. |
| Tack | Corner of sail formed by leading edge and bottom edge; to sail at angle(s) to the wind. A boat can be tacked against the wind or before the wind. |
| Taffrail | Rail around stern of boat at deck level. |
| Tiller | Steering stick attached to rudder. |
| Topping lift | Line used to raise outboard end of boom or yard. |
| Trail boards | Decorative boards at bow beneath or against bowsprit. |
| Traveler | Track, rod, or pulley system on which sheet for sail or rigging accessories can slide. |
| Trim | Position of boat in the water; position of sails relative to wind. |
| Trimming ballast | Small amounts of ballast used to make boat float exactly right. |
| Trim tab | Small adjustable plane mounted on rudder to reduce pressure on helm. |
| Trip(ping) line | Light line used to release snaps on spinnaker pole; light line used to raise anchor from fluke end. |
| Truck | Top of mast. |
| Trunk | Casing around centerboard; vertical walls of cabin above deck. |
| Tumble-home | Inboard sloping of hull sides, bow or stern above waterline. |
| Turnbuckle | A screw device for taking up slack in wires or rods. Called "rigging screw" in England. |

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| Vail (also vale, bail, bale) | Strap around boom to which sheet attaches and which allows pulley block to swing in direction of load. |
| Vang | Line used to trim peak of gaff-headed sail (a sort of sheet made fast to gaff peak); line used to hold boom from kicking up into the air when running before the wind. |
| V-bottom | Construction in which cross section of boat's bottom is actually V-shaped. |
| Wear | Archaic term from square-rigged days, to come about by heading vessel into wind, then putting helm in opposite position and letting the boat blow backward until she falls off on the other tack. |
| Well | Case around centerboard; a box for keeping live bait; a small, "foot-size" cockpit. |
| Whisker pole | Pole used to hold jib away from mast to side opposite side of mainsail when boat is running before the wind. |
| Whiting | Chalklike dust added to paint or putty to thicken it. |
| Yar | Trim, shipshape, neat. |
| Yard | Spar lying across the mast and reaching about equal distances to either side. |
| Yaw | To follow a snakelike track before the wind or seas. |

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